# Abstracts of Ph.D Theses 1990

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29 January, 1990

Dr. Harsh K. Gupta
Vice-Chancellor

# Foreword

I am pleased to see that the abstracts of successful Ph.D. Theses of this University have been put together for information and use of all concerned. The volume consists of 296 abstracts of which 66 are from Faculty of Science, 9 from Technology, 11 from Law, 45 from Social Sciences, 42 from Humanities, 1 from Environmental Studies and 122 from Marine Sciences. I sincerely hope that this volume would be useful to University community as well as all other research institutions.

Harsh. K. Gupta

Cochin University of
Science & Technology
Cochin-22
29 January, 1990

Prof. C.A. Abdussalam
Pro-Vice-Chancellor

# Preface

Though Kerala stands first among Indian states in literacy, its position, attainments and performance in higher education especially in the field of research oriented activities, are far from enviable. Computations based on a recent publication of the University Grants Commission reveal that out of a total of 31091 Ph.D.'s produced in India during the five year period 1979-84, Kerala accounts for only 412 with a percentage of 1.33 as against its population share of 3.71 percent. The coefficient of equality with respect to the national average is only 36. Lack of adequate facilities and an atmosphere conducive to research in our Universities and Colleges, the 'brain drain' of the best talents of the state to other parts of the country and to foreign countries and the resulting dearth of qualified hands to supervise research work, failure in creating an awareness and inculcating the true spirit of research work in the minds of our young post-graduates, etc. can be attributed to this deplorable state of affairs. In this context, the research work carried out in the Cochin University of Science & Technology and the 296 Ph.D's produced by it during the 18 years of its existence are silverlinings in the midst of dark clouds. As one who is responsible for the evaluation of Ph.D. theses in this University, I am happy to publish a compilation of the abstracts of all of these theses accepted by this University from 1973 to 1989 for the award of Ph.D. degrees (there were no awards in 1971 and 1972, the first two years of the existence of the University). The following is a faculty-wise break up of these theses.

| | |
|---|---|
| Faculty of Science | 66 |
| Faculty of Technology | 9 |
| Faculty of Law | 11 |
| Faculty of Social Sciences | 45 |
| Faculty of Humanities | 42 |
| Faculty of Environmental Studies | 1 |
| Faculty of Marine Sciences | 122 |
| Total | 296 |

It is heartening to note that most of these Ph.D. theses are of a high standard and have contributed their mite to the development and growth of human knowledge. Some of them have even attracted such sweeping commendations from the examiners as "thesis constitutes a very good authentic report of certain serious studies carried out", "the author demonstrates excellent experimental skill in designing and fabricating all the required tools for his experimentation", "this topical research study which upholds the high standards of research with its excellent text in lucid expression and scholastic outfit is by all standards an outstanding original contribution", "this thesis is a first-rate piece of work; the student and his research supervisor are to be commended; rarely have I encountered such an excellent body of work" etc.

Though this work relates only to Ph.D theses, it will be of considerable interest, if I mention that this University has also awarded D.Sc. degrees to Dr. R.V. Unnithan (1977) Dr. V. Santhakumari (1987) and Dr. S.A. Abbasi (1989) for their outstanding post-Ph.D. research work based on several publications in reputed journals. The studies of Dr. Unnithan and Dr. Santhakumari come under the Faculty of Marine Sciences and that of Dr. Abbasi under the Faculty of Environmental Studies.

I wish to express my deep sense of gratitude to the Heads of Departments/Schools of the University, the supervising teachers/scientists, the staff of the Examination and Academic Sections and the Office of the Pro-Vice-Chancellor for extending to me all posible help and full co-operation in bringing out this volume. My special thanks are due to SHRI. G. NARAYANA PILLAI, Personal Assistant to the Pro-Vice-Chancellor for the perseverance and efficacy he has shown while attending to the work relating to the preparation of this volume. I am extremely thankful to DR. HARSH K. GUPTA, Vice-Chancellor of the University for writing a Foreward and the encouragement extended to me in this venture. I hope this volume would be of some use to the research workers of not only the universities and colleges but also to those who carry out similar work in the industry, planning organisations, scientific institutions and the like.

(C.A. ABDUSSALAM)

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# Faculty of Science

## (Applied Chemistry)

### S.a.c. 1. RAVEENDRAN NAIR. B.–Kinetics and Mechanisam of Urea-Formaldehyde and related reactions–1988–Dr. D. Joseph Francis.

Kinetic investigations of the reactions of urea and its related compunds with formaldehyde in aqueous acid, alkaline and neutral media have been carried out. A thin-layer chromatographic method was developed for the separation and estimation of the products of these reactions. Using this technique the various initial steps in the reactions were analysed and rate constants have been determined.

A new method for preparing dimethylenetriurea and a modified method for the preparation of trimethylenetetraurea were reported. The products of the reactions of methylurea, phenylurea, acetamide andbenzamide with formaldehyde viz., MMMeU, MeBPhu, MMA, MeBA, MMB and MeBB have been prepared by the newly developed methods.

A new spraying reagent viz., phenylhydrazine sulphate—Fe (111) chloride, has been used for identifying the reaction products and their colorimetric estimation.

The reaction of urea with formaldehyde is reversible in acid, alkaline and neutral aqueous solutions. The equilibrium was found to be independent of pH in the range 3 to 10.5. The formation of monomethylolurea follows second order kinetics while the dissociation is first order. The urea-formaldehyde reaction is highly pH dependent. The rate constants being lowest in the pH range 4.5 to 8.0. Both below 4.5 and above 8.0 the rate increased rapidly with change in pH. Introduction of a methylol group was found to deactivate the urea molecule to further formaldehyde addition.

Under alkaline conditions, especially above pH 8, methylolation was the only preferred reaction and even trimethylolurea and tetramethylolurea were formed from urea and formaldehyde. In acid medium both methylols and methylene bridged compounds were formed. The formation of higher methylols were less favoured.

The various routes for methylene bridge formation were investigated and it was found that higher homologues can be formed mainly through the reaction of (i) methylenediurea with monomethylolurea (ii) methylolation of methylenediurea followed by its reaction with urea. The latter route seems to be the preferred one. The low reactivity of methylenediurea towards monomethylolurea could be attributed to the low reactivity of the amide nitrogens. Therefore the higher homologues may be formed mainly by the reaction of methylols of methyleneureas with urea and not by the reaction of methylolurea with higher methyleneureas.

Hence in the alkaline media urea reacts with formaldehyde giving low molecular weight resins containing only methylols of urea. These compunds may react with free urea in the acid medium giving methylene bridged compounds with or without methylol groups. The methylene compounds thus formed may be further methylolated in presence of excess formaldehyde and condense further with free urea present. But after the trimer stage rate of further reactions may be considerably reduced due to less reactivity of the methylol and primary amino groups of methyleneureas. The mechanism of urea-formaldehyde reaction is discussed.

The reaction of acetamide and benzamide with formaldehyde were found to be slower than that of urea with formaldehyde. Introduction of a methyl group to one of the amino groups (methylurea) increased its reactivity whereas introduction of a phenyl group (phenylurea) reduced the reactivity. The effect of substituents on the reaction rate are explained on the basis of the electron donating and electron withdrawing property of the respective groups.

## S. a.c. 2. RAMABHADRAN, P.–Synthesis and reactions of Flavazoles–1984–Dr. P. Madhavan Pillai

1-Phenylfavazole (1-phenl-1-H-pyrazolo[3, 4-b] quinoxaline) is known to be prepared by the treatment of quinoxaline-2-carboxaldehyde phenylhydrazone with phenylhydrazine. However, when stored or oxidised phenylhydrazine was used for this cyclisation, an unusual phenylation reaction was found to take place producing significant quantities of 1, 3-diphenylflavazole. This phenylation reaction was established as taking place by a free radical mechanism involving phenyl radicals formed from oxidised phenylhydrazine. Benzoyl peroxide which also produces phenyl radicals gave 1,3-diphenyl-flavazole under the same reaction conditions, thus providing additional evidence for the free radical mechanism. By using oxidised substituted phenylhydrazines, a number of new flavazoles such as 1-p-tolyl-3-phenyl, 1-(p-chlorophenyl)-3-phenyl, 1-(p-bromophenyl)-3-phenyl and 1-phenyl-3-p-tolyl-flavazoles were also prepared and characterised. The structures of these compounds were confirmed by their spectral data.

1-Phenylflavazoles with different substituents at position 3 such as the amino, chloro, hydroxy, chloromethyl, trichloromethyl, carboxamido, N-pyrrolidyl and N-pyrrolidylmethyl groups were also prepared for the first time. 3-Amino-1-phenylflavazole was prepared by two methods, i.e., the reaction of 3-chloro-1-phenylflavazole with ammonia and also by a Hofmann reaction of 1-phenylflavazolo-3-carboxamide. Other interconversions of the 3-amino, 3-hydroxy and 3-chloro-1-phenylflavazoles were also investigated.

On the new reactions of flavazoles studied, the oxidation, reduction, bromination and hydrolysis reactions are worth mentioning. Thus the oxidation of 1-phenylflavazole produced 1-phenylpyrazolo [3,4-b]pyrazine-5,6-dicarboxylic acid which was also characterised as its dimethyl ester. The flavazole ring was not easily reduced either with lithium aluminium hydride or with sodium borohydride. When 1-phenyl-flavazole was heated under reflux with sodium borohydride in isoprophyl alcohol, the heterocylic ring was broken and 2-anilinoquinoxaline-3-carboxamide was produced showing that the sodium borohydride acted only as a base rather than as a reducing agent under the reaction conditions. Also treatment of 1-phenyl-flavazole with hot aqueous sodium hydroxide again ruptured the heterocyclic ring system and produced 2-anilino-quinoxaline-3-carboxylic acid. This carboxylic acid underwent decarboxylation easily when heated giving the known 2-anilino-quinoxaline. The treatment of both 1-phenylflavazole and 1,3-diphenylflavazole with bromine in acetic acid led to clean bromination at the para position of the 1-phenyl group, thus producing 1-(bromophenyl)flavazole and 1-(p-bromophenyl)-3-phenylflavazole respectively in excellent yields.

The cyclisation reaction of several quinoxaline-2-carboxaldehyde phenylhydrazones was shown to take place by using a mild dehydrogenating agent such as azobenzene. Also the same cyclisation took place although in a lower yield when these compounds were heated at a temperature above their melting points in an atmosphere containing oxygen.

An analysis of the mass spectra of several flavazoles showed similar fragmentation patterns. Also the flavazoles have characteristic ultraviolet adsorptions as seen from the correlation of the uv spectra of a number of flavazole derivatives.

## S. a.c.3. ANNAM CHACKO, P.–Studies on the Synthesis and CNS Activity of Strychnine Derivatives–1987–Dr. P. Madhavan Pillai.

Strychnine, the major alkaloid present in Strychnos nuxvomica seeds has been reported to stimulate the entire central nervous system with preferrence for the spinal cord. It is a powerful convulsant and because of this property, it is an important pharmacological tool as it plays a unique role as an inhibitor of post synaptic inhibitory impulses. It is useful to study inhibitory transmitter and receptor types. However, because of its extremetoxicity, strychnine does not have any therapeutic application in the Western system of medicine.

The present work was undertaken with a view to obtaining strychnine derivatives having CNS stimulating properties but with sufficiently low toxicity so that they may eventually find some application in medicine. As nuxvomica seeds, its possible utilization in therapeutics will have considerable commercial significance.

A number of derivatives of strychnine were prepared. These included products with nitro, amino, acetamido, bromo and sulphonamido groups introduced at the 2 position by electrophilic aromatic substitutions and subsequent chemical conversions as required. Also reduction of the amide carbonyl group at position 10 using lithium aluminium hydride provided strychnine. Treatment of strychnine with benzaldehyde and substituted benzaldehydes yielded derivatives with benzylidene groups attached at 11-position. Similarly an oxime was obtained at this position by reaction with amylnitrite. Catalytic hydrogenation of strychnine in the presence of palladium of carbon provided the known 21-22 dihydrostrychnine which on nitration gave another derivative having nitrogroup at 2-position and with the 21,22 double bond saturated. The structures of all new compounds were established with the help of spectral data and elemental analysis. Finally a reaction of strychnine with chloroform in the presence of benzoyl peroxide yielded a trichloromethyl derivative, but the exact position of this group has not been determined. These reactions have thus yielded structural analogues of strychnine with modifications at the aromatic ring and at position 10,11 and 21-22.

There have been reports that the N-oxides of alkaloids generally modify their pharmacological properties and the N-oxide of strychnine (known as genostrychnine) is less toxic and less convulsive than strychnine itself. However, strychnine N-oxide is not being used as a therapeutic agent now probably because of the threat of convulsions at higher doses. All the derivatives of strychnine which were prepared as mentioned earlier were, therefore, converted into their N-oxides by well established procedures. Brucine N-oxide was also prepared from brucine for the same type of comparative studies.

Pharmacological studies were carried out on the derivatives of strychnine and their N-oxides. These experiments were conducted systematically on frogs weighing 40-100 g. Each does was given to a number of frogs as uniform suspension and equimolar quantities were administered and strychnine was kept as control.

Generally, the N-oxides of all compounds were less toxic and most of them showed no convulsions in accordance with earlier reports. The nitro, bromo and amino substituents at 2-positions of strychnine did not substantially change the pharmacological activity. 2-amino strychnine, 2-acetamidostrychnine and its N-oxides manifested muscle relaxant properties as well. The acetamido derivative and its N-oxide were less toxic and did not exhibt strychnine type convulsions or toxicity.

The introduction of the biologically important sulphonamido group also reduced the toxicity of the strychnine molecule and the N-oxide further decreased the toxicity as expected. Although the benzaldehyde condensation product at position 11 showed increased toxicity and convulsive property, substituted benzaldehyde condensation products provided compounds with substantially lower toxicity compared to strychnine. Their N-oxides were found to have further decreased toxicity with a similar effect on the convulsant activity. The 11-oximino derivative and its N-oxide also had reduced toxicity. Saturation of the double bond at the 21,22 position made the molecule more toxic and produced stronger convulsions. These effects were demonstrated both by dihydrostrychnine and the 2-nitrodihydro-strychnine. The N-oxides of the saturated derivatives also had correspondingly increased toxicity compared to their unsaturated analogues.

One of the products with lowest toxicity was the trichloromethyl derivative and it produced only very minor convulsions on frogs. The toxicity and convulsive property was further decreased when the trichloromethyl derivative was converted into its N-oxide. A complete pharamacological screening of these compounds are required for their further biological evaluation.

This work has provided several new compounds which are significantly less toxic than strychnine and its N-oxide as shown from the pharmacological studies. A they also possessed CNS stimulating properties, they are well suited for further screening to assess their potential as valuable therapeutic agents.

## S.a.c.4. PUSHPAKUMARI, K.N.–Studies on lemongrass oil–1988–Dr. Paul A. Vatakencherry.

Lemongrass oil contains generally about 75% of citral which is infact a mixture of geranial (citral a) and neral (citral b) roughly in the ratio of 5:3. At present citral is estimated using sodium bisulphite adducting method. Due to the presence of 2 ethylenic linkages and an aldehyde group, the bisulphite adducting is found to be complicated. Moreover other aldehydes and methyl ketones present in lemongrass oil will also get adducted, there by increasing the percentage of citral estimated. In the present work a new and efficient method has been developed for the estimation of citral using column chromatographic technique. This method has been extended for the isolation of citral in pure form, from lemongrass oil, in quantitative yields. Citral has also been separated into three fractions, pure neral; mixture of neral and geranial and pure geranial by column chromatography which was thought to be difficult. Total analysis of lemongrass oil by separation of the individual components has also been achieved using chromatographic technique.

Conversion of citral, the main component of lemongrass oil, to other industrially important components are investigated. The utility of basic alumina as the condensation catalyst for the condensation of citral with acetone for the preparation of pseudoionone, a key intermediate in the synthesis of Vitamin A, is demonstrated. Cyclisation of pseudoionone to ionones with acidic alumina soaked with para-toluene sulfonic acid has also been achieved.

ß-damascone, a valuable flavour and perfume material has been synthesized starting from citral through ß-ionone.

Citral has been condensed with the terminal allylic functionalised methyl heptenone to get the C-18 ketone, which is a key synthon for the synthesis of phytol, isophytol, Vitamin E and Vitamin $K_1$.

## S.a.c.5. LUCY JOSEPH.–Studies on Chelating ion-exchange resins–1988–Dr. V.N. Sivasankara Pillai

During the last fifty years ion-exchange method has evolved as a major technique in analytical chemistry as well as in process technology. This is mainly due to the operational convenience and versatility of the technique in achieving preconcentration and separation of anions and cations. The quest for achieving better selectivity for ion-exchange resins led to the development of resins bearing chelating functional groups. The ultimate aim was to synthesize resins specific for each kind of metal ion. Inspite of the extensive investigations, chelating exchangers are still insufficiently used in the practice of analytical chemistry due to the complexity of their synthesis and high cost.

Our study outlined in this thesis, was concentrated on preparing chelating resins with improved selectivity. Starting from polystyrene a new chelating resin, ST-3, was synthesized. It is a sulfur and nitrogen containing resin prepared by a simple three-step procedure. The thiol group is protected from oxidation by a prosthetic group. The resin is stable in 2M HCl, 0.1M NaOH and 0.1M $HNO_3$. Sorption studies of metal ions on the resin revealed its high selectivity towards mercury (II) ($K_D = 1500$) and silver (I) ($K_D = 4600$). The resin is very effective in the enrichment and recovery of mercury at ppb levels prior to determination. Results of mercury stripping studies from chlor-alkali effluents on the analytical scale are given. The resin shows promising properties in this application and reduces mercury in the effluent to an environmentally acceptable level of $< 5$ g/1 Investigation on the scale up aspects of the resin is being carried out. The resin is capable of competing with chloride ions present in high concentration in the brine effluent and the sorbed mercury can be eluted using thiourea in dil. HCl, thus effecting the recovery of the resin.

The commercially available sulfur-bearing resins are also capable of removing mercury from aqueous effluents after pretreatment to the environmentally acceptable level. Of these resins IMAC TMR and Duolite ES 465 (Diamond Shamrock) are stable in acid medium, but are sensitive to oxidants. MISSO ALM-525 (Nippon Soda) and Sumichelate Q-IOR (Sumitomo) are also capable of stripping mercury at trace levels. These being dithiocarbamates deteriorate in acid medium and are sensitive to oxidation even by mild oxidizing agents. ST-3 resin has similar sorption characteristics to IMAC TMR and Duolite ES 465 resins. It has a definite advantage that it is prepared by simple procedure and has a higher stability due to the thiol group being protected from oxidation (by mild oxidants) by an additional functional group.

Another chelating resin was prepared by electrostatically anchoring pyrogallol disulfonic acid to the commercially available strong base anion-exchange resin, Seralite SRA 400. The reagent loaded resin, R-PGC, is stable towards Fe (III), Mo (VI) and V(V). Exchange behaviour of several metal ions were studied and a comparison of $K_D$ values for various metal ions showed that R-PGS is an excellent medium for the preconcentration and separation of a number of metal ions. Thus separations of Fe(III)-Mn(II), Fe(III)-Cu(II), Fe(III)-Ni(II), Fe(III)-Mo(VI), V(V)-Mn(II), V(V)-Mo(VI) and Mn(II)-Cu(II)—Fe(III) were carried out successfully and recovery and standard deviations are reported. Elution of Cu(II), Ni(II) and Mn(II) were possible with very dil. HCl. Fe(II) and V(V) could be eluted with ascorbic acid in dil. HCl. Elution of Mo(VI) from the column was achieved using 1M $HClO_4$. The reagent loaded resin can be prepared by running the reagent solution through the anion exchange column. This is a definite practical advantage of R-PGS over chelating resins with covalently-bound functional group. Preconcentration and recovery of Mo(VI) from lean sources are also reported.

## S.a.c.6. RAMACHANDRA SHARMA, N.–Studies on the Microbial Transformation of Alkaloids : Strychnine and 2-Nitrostrychnine–1988–Dr. P. Madhavan Pillai

Microbial transformations of natural products have been a useful method for the preparation of many biologically active compounds. Although microorganisms are capable of carrying out stereospecific and regiospecific chemical transformations on a wide variety of organic compounds, their utilization has not been fully exploited on substrates other than carbohydrates and steroids. Alkaloids as a class, have received very little attention in this respect as their transformations involving heterocyclic systems are more difficult compared to allicyclic compounds. Strychnine, the major alkaloid isolated from the seeds of the Indian tree, Strychnos nuxvomica is known to stimulate all portions of the central nervous system with preference to the spinal cord. However, being a powerful convulsant it leads to death from asphyxia. As such, neither strychnine nor any of its derivatives has any therapeutic application in the western system of medicine at present.

The microbial transformations of strychnine and one of its derivatives, 2-nitrostrychnine were extensively investigated in this work. Strychnine was subjected to the actions of a variety of microorganisms with a view to convert it into a product of less toxicity and improved pharmacological activity. Many of the cultures obtained from the National Collection of Industrial Microorganisms (NCIM) failed to convert strychnine into any useful products. Of these organisms only *Bacillus thuringiensis* 2159, *Cunninghamella blakesleeana* 687 and *C. echinulata* 691 produced the N-oxide in small amounts and this process itself is of no practical value as the same product can be obtained in better yields by chemical methods. Hence organisms that grow on strychnine were isolated from the loal soil using the elective culture technique. The isolated organisms were purified and the auxxenic strains were identified upto the generic level according to Bergey's Manual of Determinative Bacteriology, based on their morphological, cultural and biochemical characteristics. The strains were identified as belonging to *Arthrobacter* species. The growth of the organism under varying physicochemical environmental factors such as temperature, pH, sodium chloride concentration and substrate concentration were studied to arrive at the optimal conditions. Similarly, the influence of a second carbon source, glucose on the rate of transformation was also investigated. The kinetics of utilization of strychnine was studied by subjecting the fermented broth to exhaustive extraction using chloroform-methanol and estimating the concentration of the substrate in the extract at specified time intervals spectrophotometrically. The progress of strychnine utilization was also followed using thin layer chromatography. These date also gave an idea about the optimum incubation period required.

By incorporating the optimal conditions of physicochemical parameters and incubation time, experiments were designed to isolate the transformed product. The fermentation was carried out for 14-18 hours, the fermented broth was made alkaline to pH 9 using ammonium hydroxide and the solvent (water) was removed under reduced pressure. The residue was extracted with methanol and the crude product was purified by column chromatography to give about 10% of $C_{16}$-Hanssen acid. The identify of the product was established by comparison with an authentic sample of $C_{16}$-Hanssen acid obtained by the oxidation of brucine by a known procedure and also by conversion into its perchlorate and methiodide and comparison of their physical constants.

The isolated strain, *Arthrobacter* sp. ACM 1 could not produce a substantial yield of the product $C_{16}$-Hanssen acid because the organism was also found to degrade this product further. Also the same strain failed to act on brucine which is the dimethoxy derivative of strychnine and which occurs in *Strychnos nuvomica* seeds alongwith strychnine. The studies also revealed that the microorganism utilised strychnine alone in a mixture of strychnine and brucine and this method can therefore be used to purify the commercially available brucine. That the bacterial strain is able to utilise strychnine both as a carbon and nitrogen source indicates that it differs from the earlier reported *Arthrobacter strychnovorum*, which could utilise strychnine only in the presence of an external inorganic nitrogen source. Also the fact that it produced $C_{16}$-Hanssen acid and did not metabolise brucine establishes that it is different from A. *strychnophagum* also reported previously.

Transformation of 2-nitrostrychnine into 2-aminostrychnine was carried out using another organism, also isolated from the local environment. This organism was identified to the generic level and was shown to belong to *Pseudomonas* species. Here also the growth of the organism under varying physiochemical parameters were investigated to obtain the optimal conditions. These optimal conditions were incorporated and the kinetics of transformation was followed by analysing the chloroform-methanol extract of the broth using high pressure liquid chromatography. Employing the optimum physiochemical factors and incubation time, fermentation of 2-nitrostrychnine was carried out to isolate the product, 2-aminostrychnine. Its identity was established by comparison wih an authentic sample obtained by chemical reduction of 2-nitrostrychnine. This Pseudomonas strain, ACM 11 apparently contains a nitroary[1] reductase enzyme system because the same culture was also able to reduce aromatic nitro compounds to the corresponding ary[1] amines. The low yield of 2-aminostrychnine indicates that the amine formed was further broken down by the same organism.

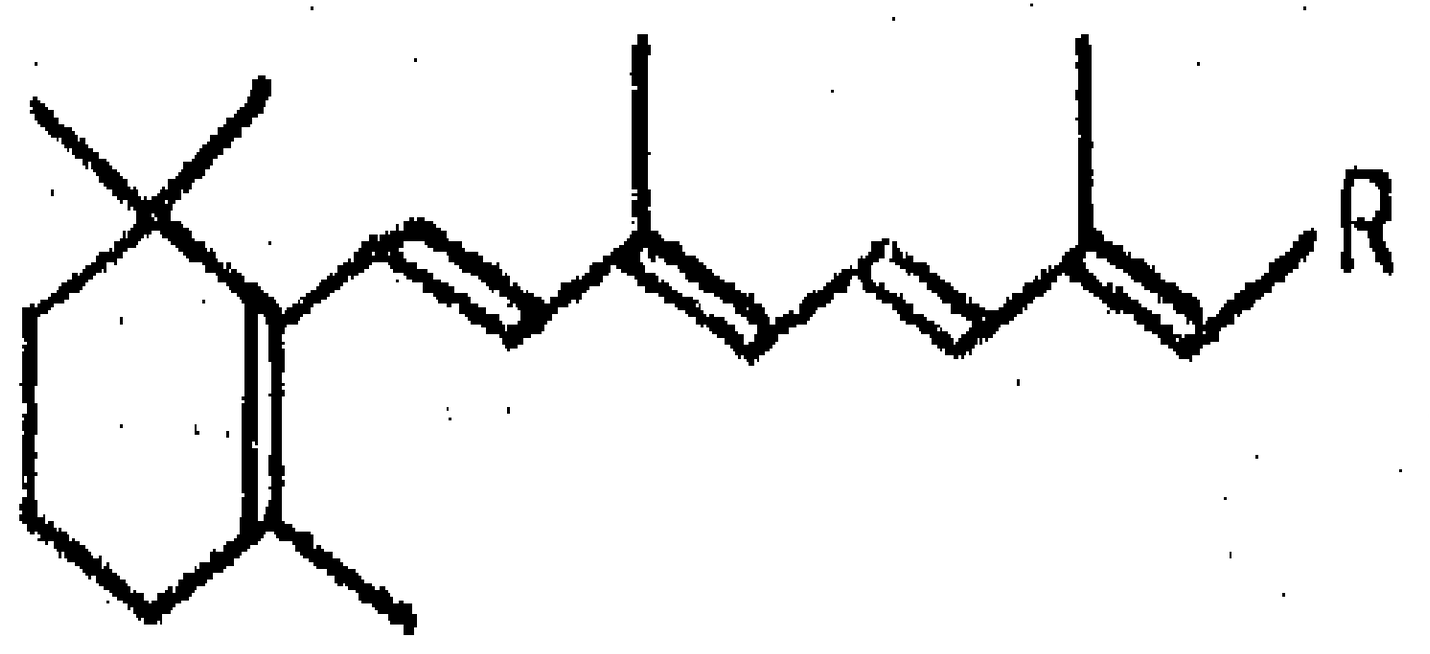
This study, thus has led to the isolation of two new microorganism, one belonging to *Arthrobacter* species that selectively degrades strychnine into $C_{16}$-Hanssen acid and the other, belonging to *Pseudomonas* species that reduces

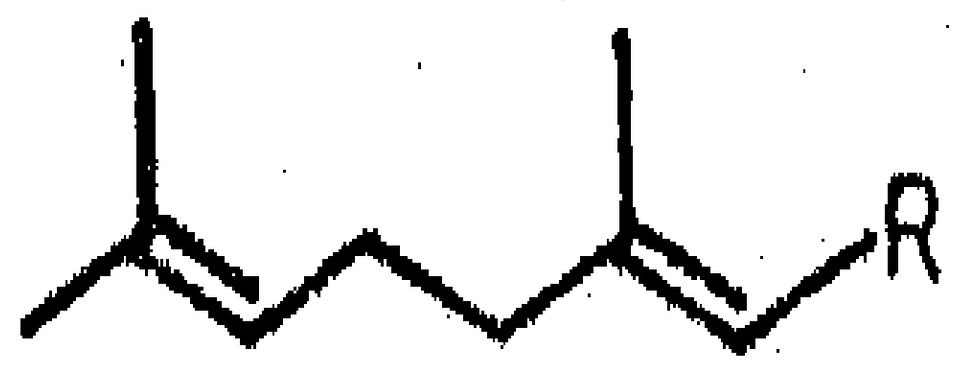
2-nitrostrychnine into 2-aminostrychnine. The characterisation of the microorganisms upto the generic level, their growth studies under different physiochemical parameters and the proof of the structures of the transformation products have been presented in detail.

## S.a.c.7. JOSE DAVID, P.–Studies on the synthesis of Vitamin-A and related compounds–1989–Dr. Paul A. Vatakencherry

In the first chapter an overview of retinoid research with special reference to the synthesis of retinoids is presented. The review though not exhaustive highlights the important achievements in the field of retinoid synthesis including the industrial aspects.

The importance of retinoids and their isomers, because of their biological activities and possible therapeutic applications, calls for developing new methodologies for their syntheses. Vitamin A or Retinol (1) a prominent member among retinoids and its simple derivatives like retinoic acid (1a) gained importance, after their role in the process of vision and therapeutic applications mainly in cancer therapy, was established. The other equally important derivative of Vitamin A is Vitamin A aldehyde or Retinal (1c). In this regard, devising practical new approaches for syntheses or improvements in the existing methods for the synthesis of these class of biologically important compounds is of more than academic interest. In the second chapter the scope of the present work is presented with synthetic schemes envisaged.

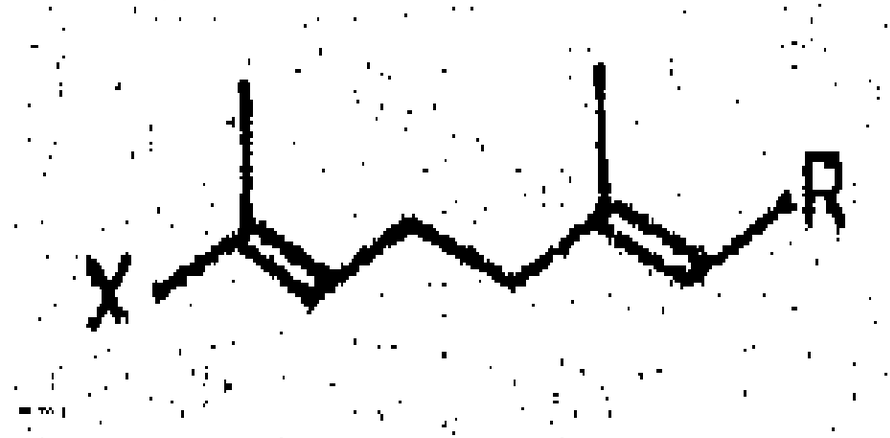




1, R = $CH_2OH$ 2 – R – $CH_2OH$
1a, R = COOH 2a – R – CHO
1b, R = CHO

Considering the above, the synthetic strategy planned are presented. The starting materials geraniol (2) and/or citral (2a) are considered because of their easy availability. Since different modes of coupling using most of the fragments are known, stress is given on the synthesis of intermediates which can act as synthons for Vitamin A synthesis. Different approaches for the necessary functionalisation for the required intermediates are presented.

$C_{10} + C_{10}$ approach is one of the important modes of building the $C_{20}$ skeleton. Different methods of allylic functionalisation, and further elaboration to synthesise the fully conjugated $C_{10}$ unit are described.



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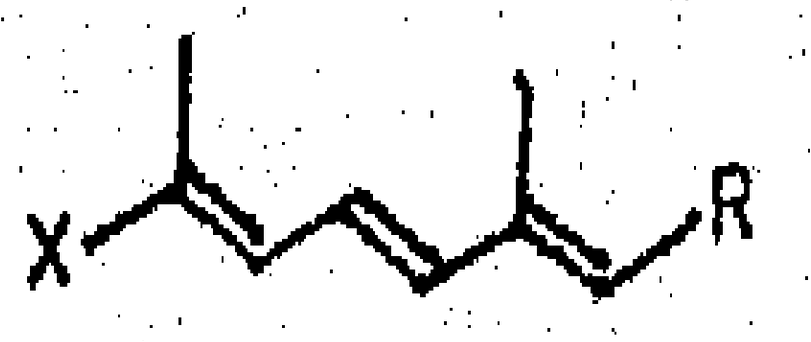

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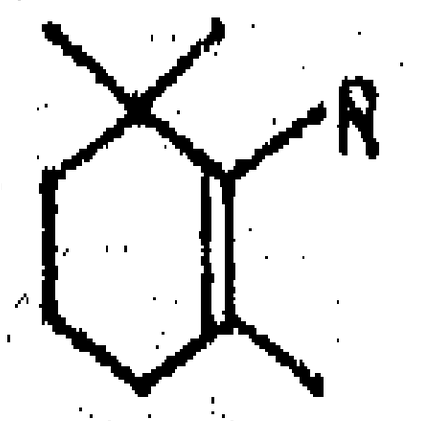

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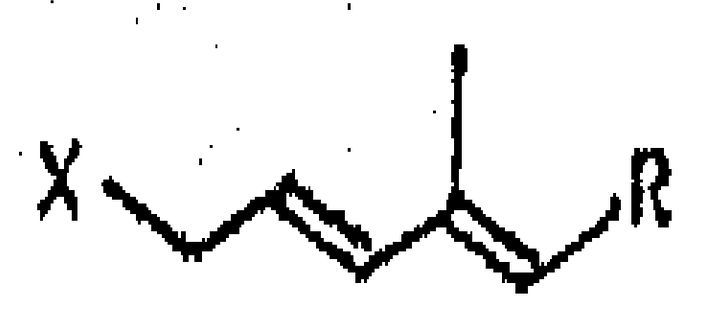

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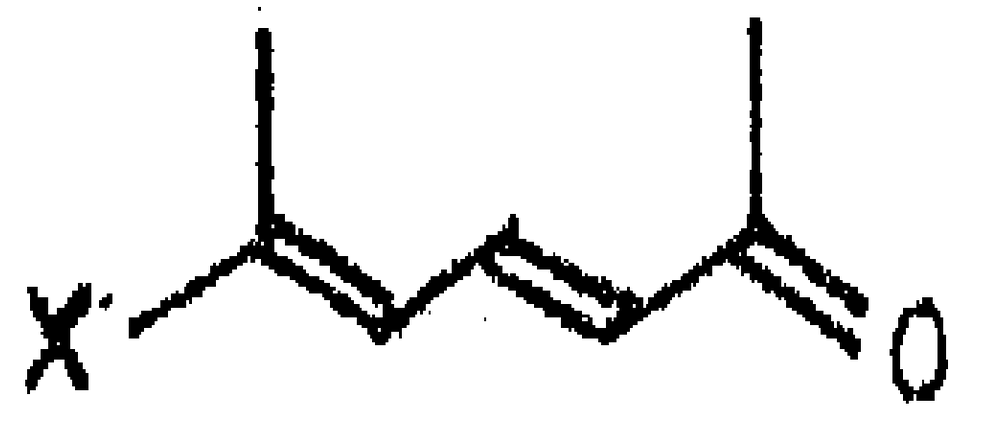
X-$CH_2OH$, CHO X–$CH_2OH$, CHO R = $CH_2OAc$

Allylic functionalisation using $SeO_2$, NBS, epoxide opening, PhSCl and singlet oxygen to get 3 are described. Introduction of double bond to get 4 using reagents $(PhSe)_2/NaBH_4$, $I_2/Cu\ (OAc)_2$, PhSCl, tBuOOH/PDC, NBS, and an electrochemical method are described. The necessary functionalisation to synthesise the cyclic $C_{10}$ part of Vitamin A 5 is described employing sulfone cyclization, PhSCl and PhSeCl reagents. Novel method for cyclization to cyclocitral starting from geranic acid together with the classical approach is also presented.

A method for the preparation of $C_7$ synthon 6 for Vitamin A synthesis is presented. Similarly a short approach for the synthesis of $C_8$ unit 7 derived from methyl heptenone is also presented. Another versatile industrial $C_8$ intermediate 8 for Vitamin A synthesis was prepared and functionalised to get 7.



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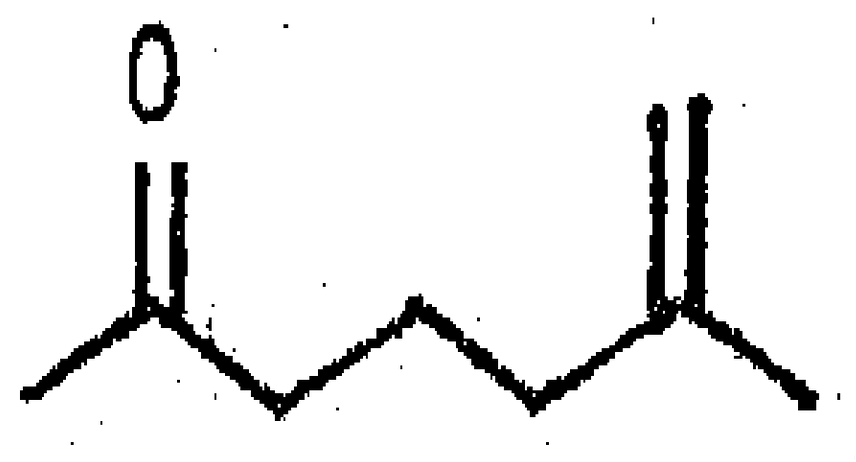

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X = $CH_2OH$ or CHO

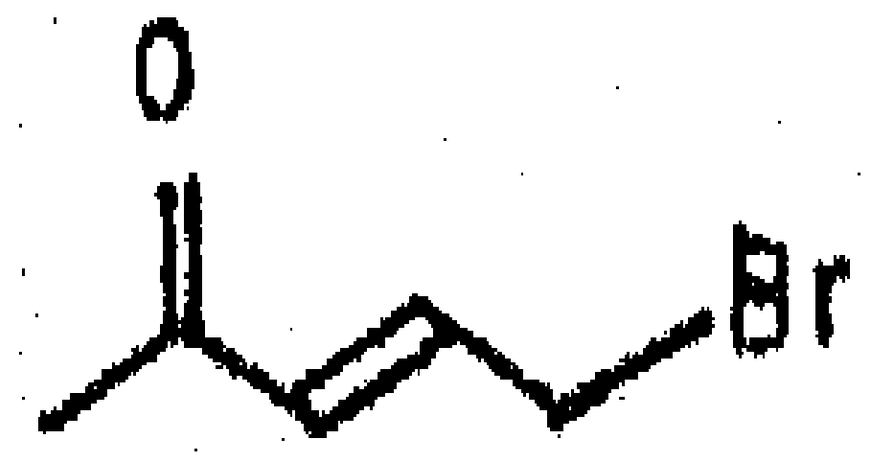
Synthetic approaches to the $C_5$ unit 9 derived from, Levulinic acid and 2-Acetyl butyrolactone is also described.

The coupling schemes involving $C_{10} + C_{10}$ and $C_{13} + C_7$ approach are described using Wittig, Wittig-Horner and sulfone alkylation. Double elimination variationof sulfone alkylation is also described.

Synthesis of the $C_{18}$ ketone (10) - a key intermediate - in the synthesis of Vitamin A is effected through $C_{13} + C_5$ and $C_{10} + C_8$ routes. Here also Wittig, Wittig-Horner variation and sulfone alkylation mode of coupling are used. The double elimination variation of sulfone alkylation is also attempted.

Since the conversion of this $C_{18}$ ketone to Vitamin A is known, this convergent approach constitutes a formal synthesis of Vitamin A. The $C_{13} + C_7$ approach too is a novel method for Vitamin A synthesis.

In the third chapter the results are discussed analysing the various aspects of the synthetic schemes. In chapter four is given the experimental details, and the list of references cited are given at the end of the thesis.



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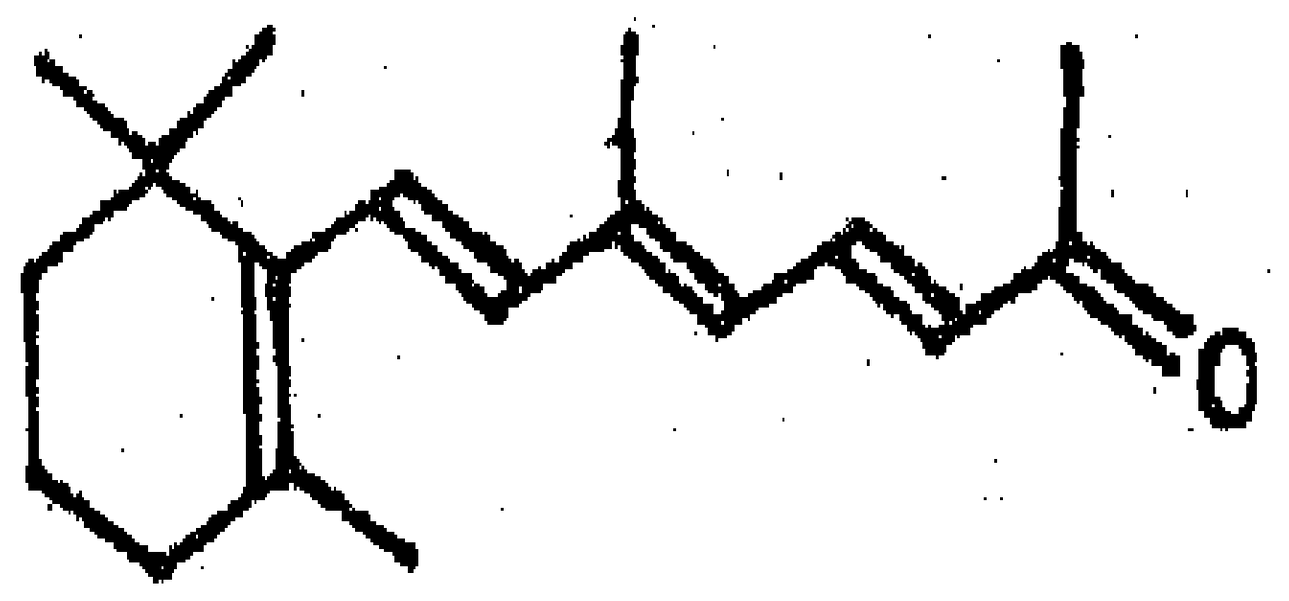

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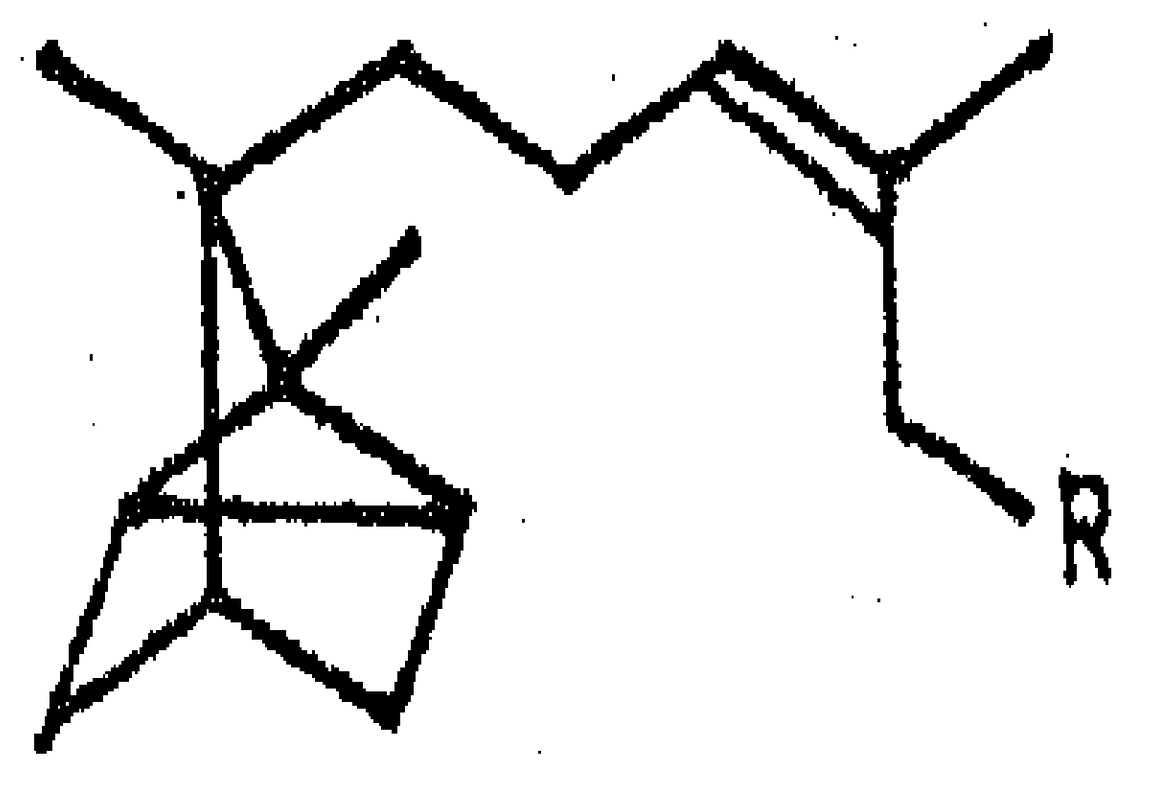
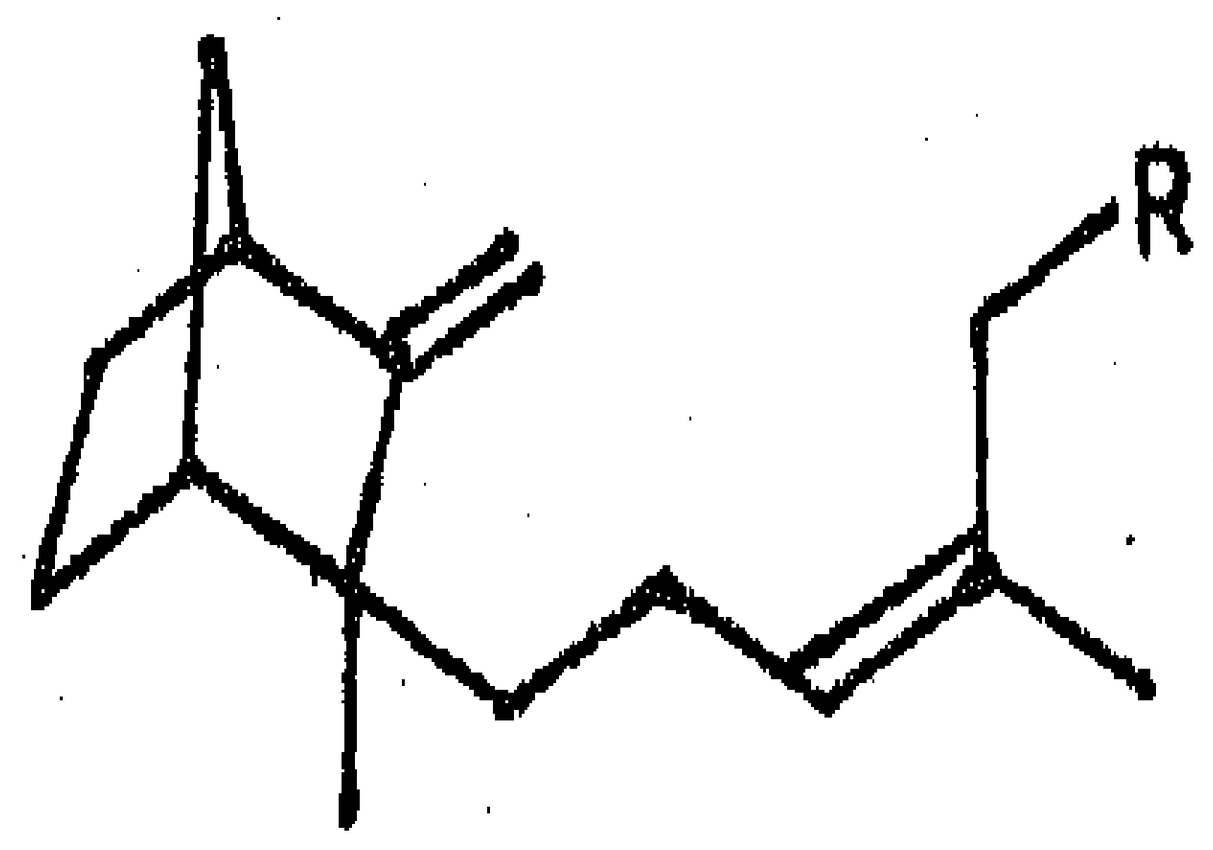
## S.a.c.8 UNNIKRISHNAN, P.A.–Studies on the synthesis of β-Santalenes, β-Santalols and related compounds–1989– Dr. Paul A. Vatakencherry.

The main components responsible for the fragrance of East Indian Sandal

Wood [Santalum album(Linn)] oil are ∝ -and ß-Santalols. The corresponding hydrocarbons namely ∝ - and ß-santalenes constitute the major hydrocarbons present in this very valuable oil. It must also be possible to convert these hydrocarbons to the more valuable santalols by suitable synthetic manipulations. Their structural characteristics i.e. presence of bicyclo [2.2.1] heptane system, geometry of the double bond in the side chain, and orientation of substituents in ß-santalenes and ß-santalols, as well as the perfumery properties especially that of ß-santalols have stimulated active synthetic studies on these and related compounds. ß-Santalenes and santalols have been synthesized in connection with structure elucidation studies. Because of their commercial importance many new methods and routes have been developed to synthesize these and related compounds of perfumery value.

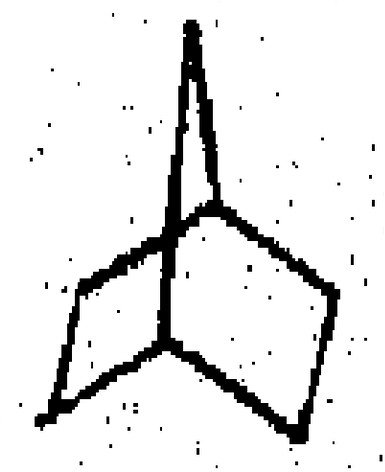


R = –H –santalene
R = –OH –santalol



R = –H ß– santalene
R = –OH ß– santalol

The thesis describes studies on the synthesis of ß-santalenes, ß-santalols and related compounds. It is divided into three chapters. Chapter - I is an introduction which is an upto date review of the synthesis of ∝ - and ß-santalenes and santalols. Chapter - II discusses the scope of the work and the synthetic strategy involved in the present study. The basic strategy involved in the work is the elaboration of suitably functionalised bicyclo [2.2.1] heptane (1) skeleton to ß-santalenes and ß-santalols. A suitably functionalised $C_5$ unit (2) that can be easily prepared which after attaching to bicyclo [2.2.1] heptane system is transformed to ß-santalenes, ß-santalols and related compounds, is employed to yield key synthons 3 and 4. These are transformed into the required ß-santalenes ß-santalols and related compounds. Synthesis of 3 and 4 and the various procedures described in the thesis allow synthetic manipulations of these to yield not only ß-santalenes and ß-santalols but also a variety of compounds of interest for studying structure-odour relationships for drawing structural parameters required for a molecular skeleton and functionality that will have useful sandalwood like fragrance and olfactory properties.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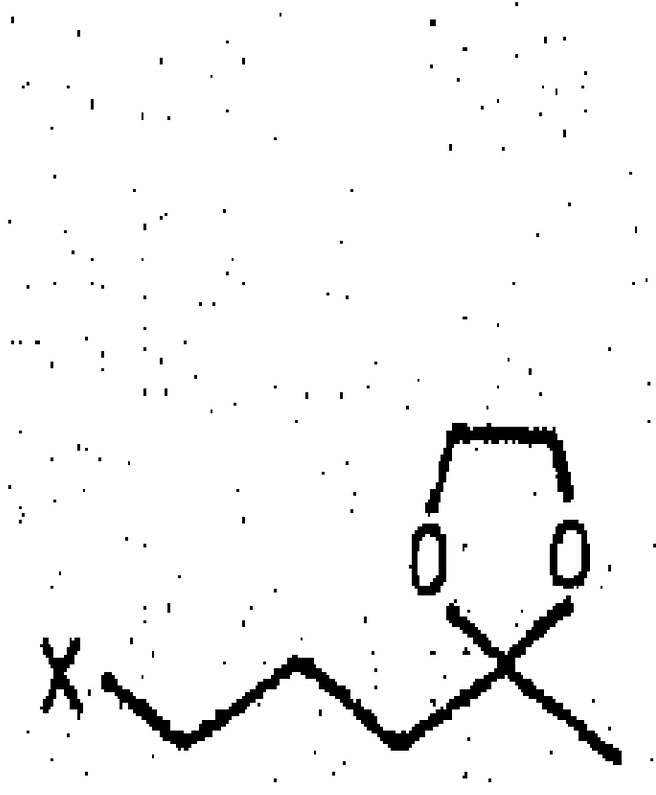

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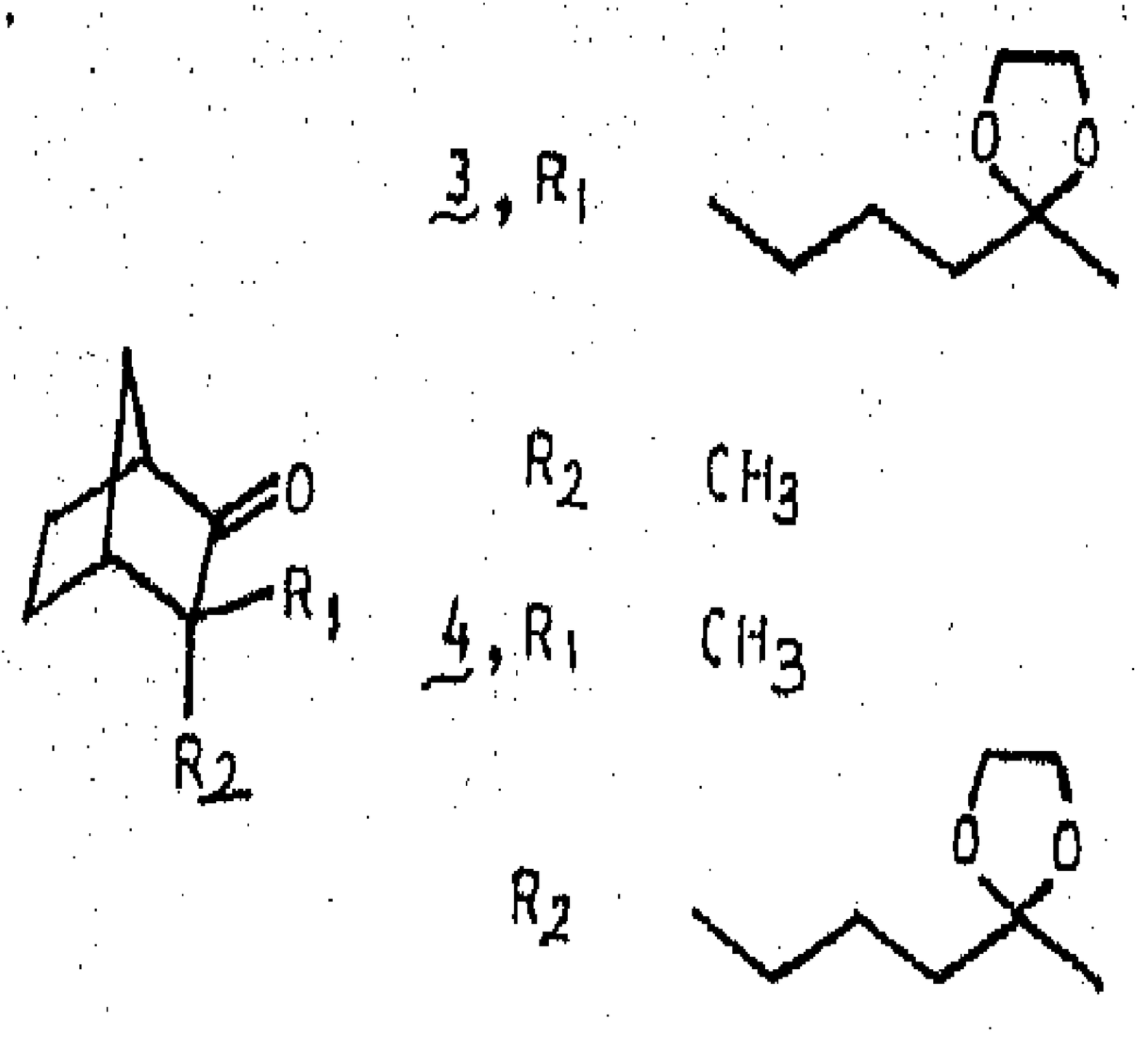
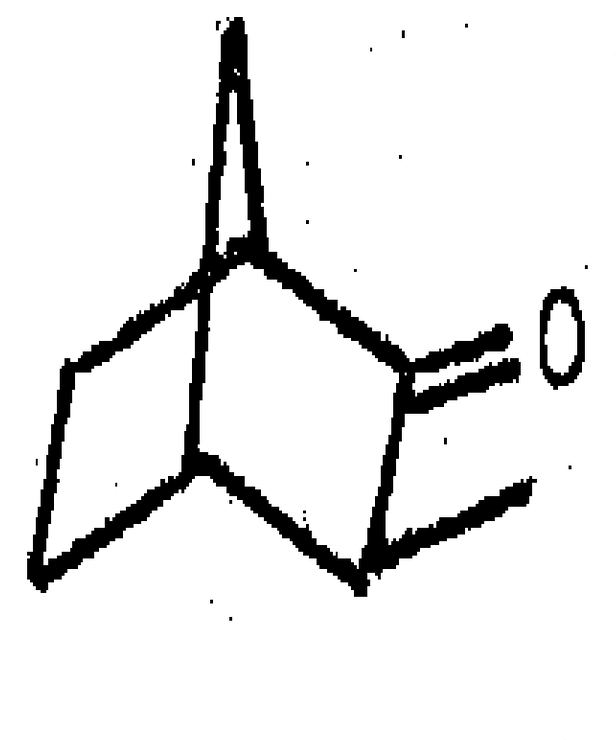


Mythyl derivatives 5 and 6 were prepared from 7 using two different methodologies. The r -bromoketal (8) was prepared in a two step process in high yields. Alkylation of 5 and/or 6 with 8 is described to get the synthon 3 suitably functionalised for further elaboration to the target molecules. A reverse sequence of reactions to get 4 and an approach to get 3 through through 9 by a different route are also described. Subjecting 10 and 11, obtained from 3 and 4 to a sequence of reactions namely with excess of $CH_3MgI$ followed by $SOCl_2$/pyridine and alternatively with $CH_2^+$ P $Ph_3Br^-$ at the carbonyl functions and attempts to rearrange the terminal olefin at the side chain completes the approach for ß-santalenes. The compounds 3 and 4 when converted to 12 and 13 give potential synthons for more valuable ß-santalols. Procedures for effecting this and allied conversions are described. This divergent approach is expected to yield ß-santalenes, ß-santaols and other molecules of interest having ß-santalene skeleton easily.



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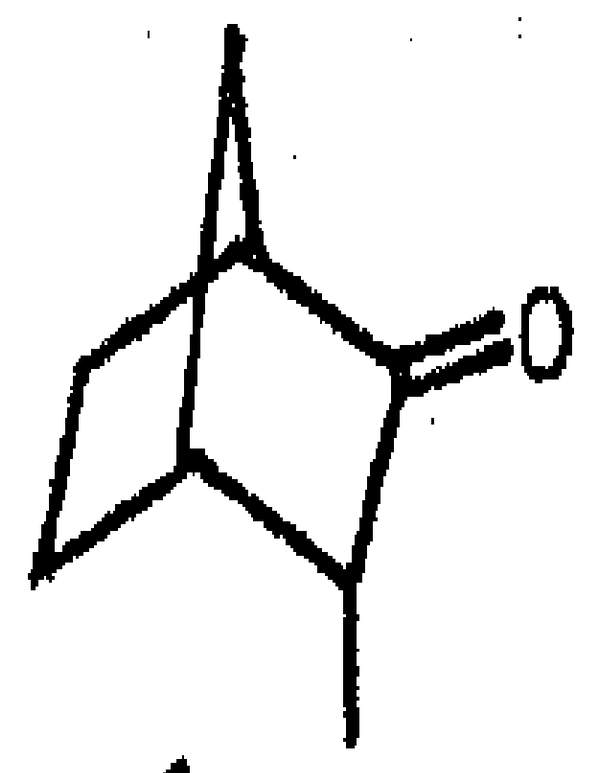

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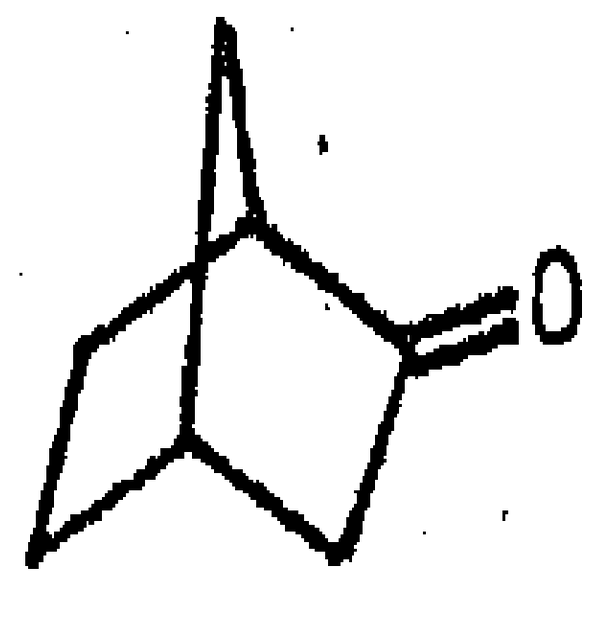

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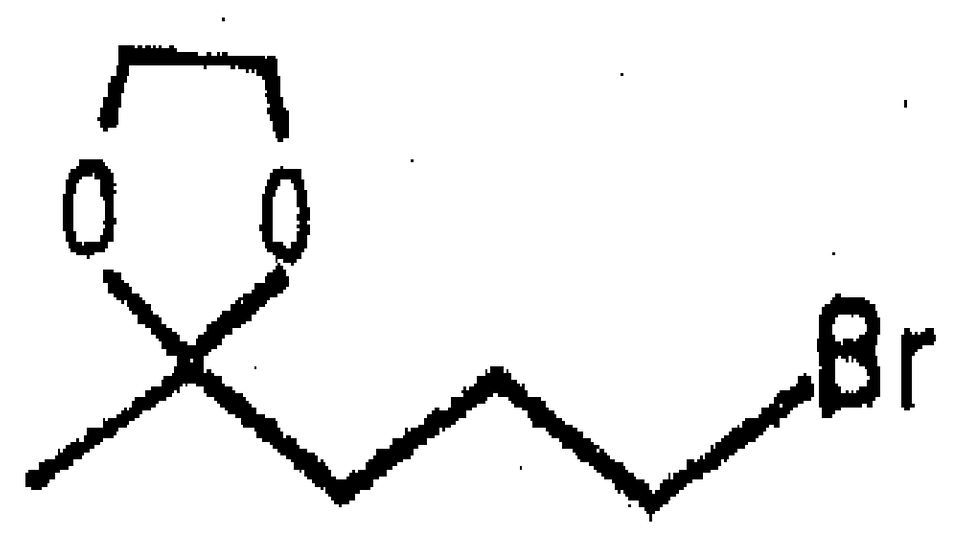

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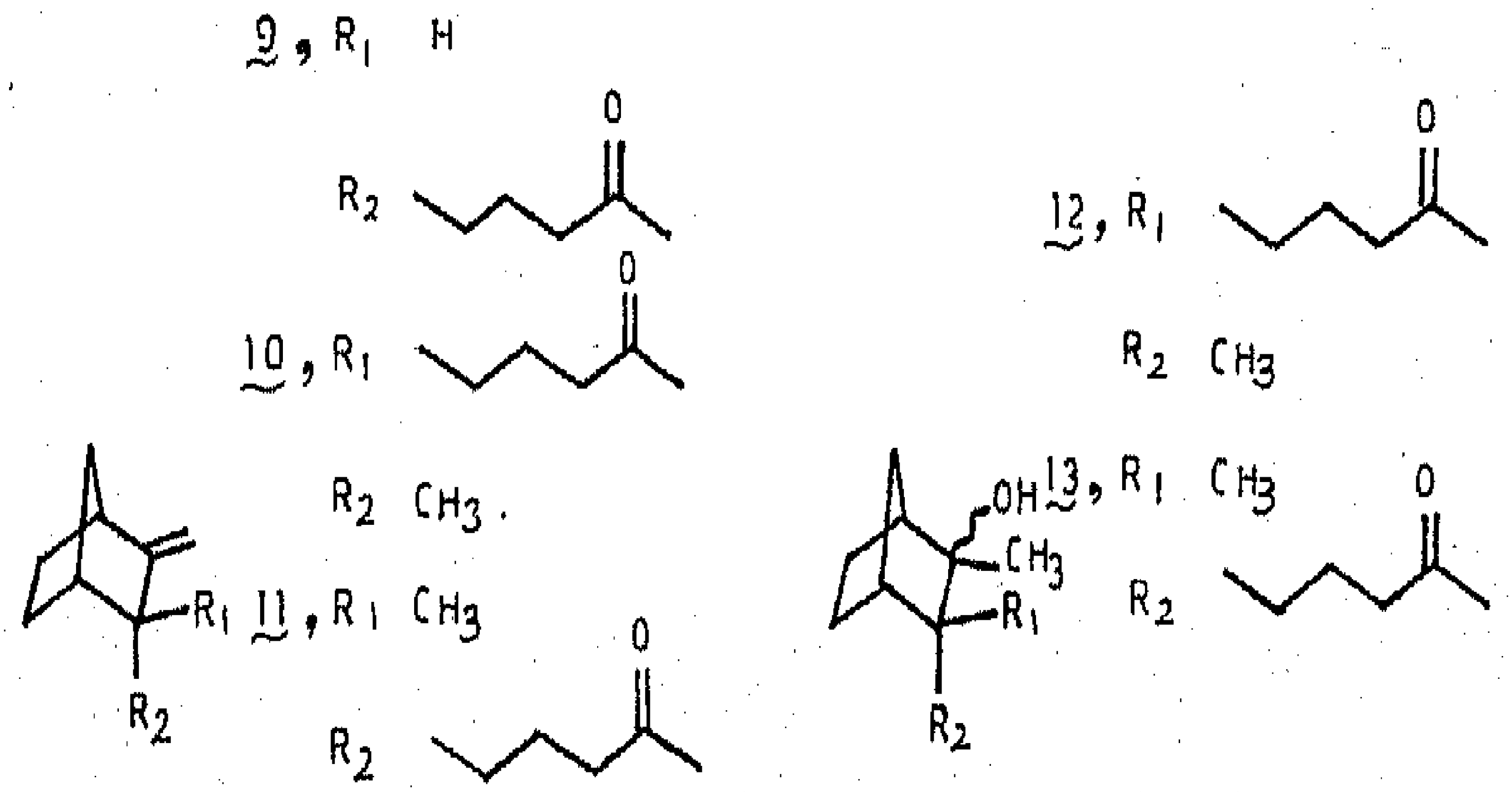

Chapter-III deals with experimental procedures and Chapter-IV is a discussion of results obtained and conclusions based on the work. The list of references is given at the end of the thesis.

## S.a.c.9. ABDUL RASHID, K.K. – Structural Studies on Some Metal Complexes of Embelin – 1987 – Dr. P.N.K. Nambisan and Jacob Chacko.

Benzoquinones and their substituted derivatives are well known as versatile redox agents and are among the most pervasive natural products on the earth's surface. They possess numerous biologically significant properties and are present in several living organisms. Embelin (2, 5 – dihydroxy-3-undecyl-1, 4-benzoquinone or 2,5-dihydroxy-3-undecyl-2, 5-cyclohexadience-1, 4-dione) an orange pigment isolated from the berries of the Indian shrub Embelia Ribes is of great medicinal importance because of its anthelmintic, analgesic and antifertility properties. Biological studies on embelin have received considerable amount of attention in recent years. However, only very scant information is available on the metal chelates of embelin which could function as possible basis for the development of therapeutic drugs. Hence a systematic study of the preparation and properties of some metal complexes of embelin has been undertaken in view of its relevance in biological systems.

This thesis deals with the studies on the synthesis and characterisation of the complexes of embelin with manganese (II), cobalt (II), nickel (II), copper (II), zinc (II), cadmium (II), chromium (III) lanthanum (III), praseodymium (III) neodymium (III) samarium (III), gadolinium (III) dysprosium (III), yttrium (III) thorium (IV) and uranium (VI).

Coordination polymers, biological aspects of embelin and coordination of metal ions with biologically important ligands have been discussed in detail. Elemental analysis as well as spectral, thermal and magnetic data were used to ascertain the composition of the complexes and to establish the structures of the metal complexes. Wherever possible, the electronic spectra and magnetic dta were used to predict the sterio-chemistry of the complexes.

Analytical data of the metal complexes of embelin indicated a metal to ligand ratio of 1:1 in the magnganese (II), cobalt (II), nickel (II), copper (II), zinc (II), cadmium (II) and uranium (VI) complexes. The chromium (III), iron (III) and the lanthanide complexes exhibited an M:L ratio of 2:3. A ratio of 1:2 was observed for the thorium (IV) complex.

Infrared spectral data indicated that embelin behaved as a tetradentate ligand in all these complexes, coordinating through its carbonyl and phenolic oxygens.

Electronic spectra and magnetic studies indicated a tetrahedrally distorted planar coordination for copper (II) complex and tetrahedral coordination for chromium (III) and iron (III) complexes. Four-coordinated structures have been proposed for the lanthanide complexes. Thus the manganese (II), cobalt (II), nickel (II), zinc (II), and cadmium (II) complexes were octahedral; thorium (IV) complex was eight-coordinated and uranyl complex was six-coordinated.

On the basis of procedural decomposition temperatures (from thermoanalytical data) all the metal chelates investigated were shown to have enhanced thermal stabilities upon complexation. However, the divalent metal complexes of embelin were found to be thermally more stable than the iron (III), the chromium (III), the lanthanide and the actinide complexes.

# Faculty of Science

## (Mathematics and Statistics)

### S.m.1. VELUKKUTTY, K.K.–Some Problems of Discrete Function Theory–1982–Dr. Wazir Hasan Abdi.

This thesis is a study of discrete analytic functions defined on the lattice $\{q^m x_0, q^n y_0)/ m,n \in z\}$ when $(x_0, y_0)$ is a fixed point in C and q is a fixed number in (0,1).

In the discrete function theory, the differential operator of the classical complex analysis is replaced by a suitable difference operator. The theory of discrete functions had its start from R.P. Isaac's (1941) work who introduced two types of difference operators to describe analyticity namely monodiffricity of the first and second kinds. Ferrand (1944), Duffin (1956), Abdullaev are some of the names who developed discrete function theory. The theory developed by these people has been mainly in the Gaussian lattice. q-difference theory was developed by Jackson, Hahn and Abdi and using this theory C. Harman (1972) developed a discrete function theory on the lattice $\{(q^m x_0, q^n y_0)\}$

This thesis starts with the investigation of functions which are both p-and q-analytic in certain domain in the discrete geometric space. The solution is named bianalytic function. The continuation of such a function from two adjacent rays is examined. Then the problem is generalised as investigation of functions having p-and q-residues equal. It is found that such functions satisfy the notion of monodiffricity of second kind in the geometric lattice. Such functions are now named q-monodiffric functions.

Monodiffricity of second kind was not studied earlier in detail. Duffin and Harman had mistaken preholomorphicity as equivalent to this–which has been disproved in this thesis.

In the second chapter of thesis, q-monodiffric differentiation is discussed in detail, q-monodiffric constant which is the general solution of the derivative equation: first derivative is equated to zero, is studied.

In discrete function theory, the concept of construction of an entire discrete analytic function from its discrete analyticity in a known domain, using the difference operator defined to describe the discrete analyticity is important. In this thesis, the construction of bianalytic function and q-monodiffric function is explained. Bifunctions and q-monodiffric constants are well-studied. They stand to replace the concepts of functions and complex numbers respectively of the classical complex function theory. The condition that the usual product of two q-monodiffric functions in a given domain is also a q-monodiffric function there is also obtained and analysed.

Among the three approaches to analytic function theory, the second, namely through the Cauchy integral is considered in the third chapter, whereas the third, namely through power series is dealt with in the fourth chapter. Here two types of integrals are defined either of them will not stand as a counterpart to the classical integral. But both of them taken together represent the theory of integration in q-monodiffric theory and plays the same role of classical integration. Fundamental concepts of integration like Cauchy's integral formula and theorem are developed in the q-monodiffric sense. Meromorphic functions along with pole and polar residue is studied. The relation between these intregrals is also obtained.

The second difficulty in the formulation of the theory is solved by introducing discrete powers in the q-monodiffric sense which leads to the third approach namely representation of discrete analytic functions in the form of an infinite series in terms of discrete powers. Unlike the previous theories, results like nth discrete power of z has exactly n zeros hold in this theory. Some estimates of discrete powers are evolved. Using these estimates convergence of infinite series is discussed. Also a comparison test to decide the convergence of infinite series is found.

The last few sections of the fourth chapter deals with polynomials and zeros of them. Mainly three types of polynomials are studied: polynomials defined over complex numbers, biconstants and q-monodiffric constants. Quadratic-polynomials of each type are exercised in detail with roots of unity in the q-monodiffric sense (ie. the zeros of $z^{(n)}=1$).

Lastly, some special polynomials are discussed. A theory to classify the discrete polynomials is obtained and some special polynomials are classified in this line. Description of a set of discrete polynomials using generating functions is completely discussed in the final chapter.

## S.m.2. MERCY K JACOB.–A study of Discrete Pseudo Analytic Functions–1983–Dr. Wazir Hasan Abdi and Dr. T. Thrivikraman

This thesis is a study of discrete pseudoanalytic functions defined on the lattice $\{(q^m x_0, q^n y_0)/m,n \in Z\}$ where $(x_0, y_0)$ is a fixed point in C and q a fixed number in (0,1).

The theory of discrete functions had its start from R.P. Isaac's work (1941). Isaac and people like Ferrand, Duffin and Abdullaev developed the theory mainly on the Gaussian lattice. q-difference theory was developed by Jackson, Hahn and Abdi and using this theory C. Harman (1972) developed a discrete analytic function theory on the lattice $H = \{(q^m x_0, q^n y_0)\}$

The theory of pseudoanalytic functions is a generalisation of the theory of analytic functions. When the generator becomes the identity ie, (1,i) the theory of pseudoanalytic function reduces to the theory of analytic functions. This thesis develops a discrete analogue of this theory. In the first chapter of the thesis, an outline of the theory of pseudoanalytic functions in the classical continuous case and also a survey of the discrete function theory are given.

The second chapter deals with the definition of Holder-type discrete functions and generating vecotrs. Their properties have been examined. Using q-difference equations modulo g, whre g is a generating vector, definitions of discrete g-pseudoanalytic functions of the first and second kind are given and their properties studied. We denote the class of all discrete g-pseudoanalytic functions of the first kind in a discrete domain D by ${}_1{}^{P}{}_D(g)$ and that of the second kind by ${}_2P_D(g)$. The real and imaginary parts of the elements of ${}_2P_D(g)$ satisfy a linear elliptic system of partial q-differenc equations of the second order with Holder-type coefficients.

Concepts of g and $p_g$-integration in the discrete system are introduced and their properties examined. In chapter 3, it is established that the g-integral of a discrete function is an element of ${}_1P_D(g)$ and $p_g$-integral of a discrete function is an element of ${}_2P_D(g)$.

Solutions of partial q-difference equations modulo-g and an analogue of Beltrami's equations are discussed. Properties of solutions thus obtained are established through examples in the fourth chapter.

The discrete g-derivative of an element of ${}_1P_D(g)$ is not in general an element of ${}_1P_D$ (g). However, there does exist a generating vector $g^{(1)}$ such that the discrete g-derivative is an element of ${}_1P_D(g^{(1)})$. We call $g^{(1)}$, a successor of g and g, a predecessor of $g^{(1)}$. It is shown that if $g = [g_1\ g_2]$ then $[g_1/i\ g_2/i]$ is a successor of g. Also any generative vector equivalent to $[g_1/i\ g_2/i]$ is also a successor of g. We have discussed the concept of a generating sequence and the periodicity of the generating sequence. It is established that if $w \in {}_1P_D{}^{(g)}$ is not a g-pseudoconstant then g can be embedded in a generating sequence of minimal period one if and only if the first component of the generating vector is equal to the product of the second component and a function of y alone. It is also established that any generating vector g can be embedded in a generating sequence of minimal period 2.

A product of two elements of ${}_1P_D(g)$ is not in general an element of ${}_1P_D(g)$. In the last chapter of the thesis, some sufficient conditions under which $w^2$, aw + b are elements of ${}_1P_D(g)$ where $w \in {}_1P_D$ (g) and a and b are complex constants. Also sufficient conditions for a quadratic in $w^* = aw+b$ to be an element of ${}_1P_D(g)$ are obtained. Also these for a cubic and in general an $n^{th}$ degree polynomial to be an element in ${}_1P_D(g)$ are obtained.

## S.m.3. SYED AFTAB HUSAIN RIZVI–Some Aspects of History of Indian Mathematics in 18th and early 19th Century–1984–Dr. Wazir Hasan Abdi and Dr. T. Thrivikraman

This thesis is an attempt to throw light on the works of some Indian Mathematicians who wrote in Arabic or Persian. In the introductory chapter, an outline of general history of Mathematics during the eighteenth and nineteenth centuries has been sketched. During that period, there were two streams of Mathematical activity. On one side, many eminent scholars, who wrote in Sanskrit, held the field as before without being much influenced by other sources. On the other side, there were scholars, whose writings were based on Arabic and Persian texts but who occasionally drew upon other sources also.

In chapter II, importance of Geometry and transmission of Euclidean geometry in India has been discussed and contribution of Indian mathematicians in this area outlined.

The third chapter is devoted to the life and work of an important Indian Mathematician, Ghulam Husain Jaunpuri (b. 1790). One of his works, Jame-i-Bahadurkhani, has been called an "Encyclopaedia of Mathematical Sciences". A portion of this work dealing with Euclidean Geometry has been translated here into English.

Chapter IV is based on Section I of Jame–i–Bahadurkhani which deals with Definitions, Objects and Principles of Geometry. A detailed critical study of the concepts and comparison with similar literature has been made. In this connection, the work of contemporaries like Mohammed Hasan b. Dildar Ali, Mir Mohammed Hashim, Sheikh Barkat Allahabadi, Jagannath Samrat, Diwan Kanhji Mal Kayastha and some modern writers have been specially mentioned.

Chapter V is concerned with the Theorems and Problems contained in Section two dealing with the properties of straight lines, Angles and Rectilinear surfaces. It consists of 49 Propositions in which 38 are taken from the Book I and II from Book of II of Tahrir-i-Uqlides by Nasir al-Din al Tusi, 1 from Appollonius work and in 9 Propositions, prrofs are given by Ghulam Husain.

In Chapter VI, Properties of Circles and Arcs, Lines and Angles, which are produced by the comparison of Circles are established. This is Section 3 of Jame-i-Bahadurkhani. It consists of 35 Propositions in which 28 are from Book III, 6 from Book IV and 1 from Blunt's book. A comparative study of these propositions have been done.

The first 21 Propositions of Chapter VII bring out the logic behind the theory of Ratios and the Rules of Simple, Compound and Derivative Proportion. This theory of Proportion is aplied in proving 18 Propositions of Book VI concerning similar triangles, parallelograms and polygons. Three propositions are taken from Nasir al-Din al-Tusi's version of Ptolemy's Megale Syntax, one from Conic sections of Archimedes, two from Talimat of Ibn Haitham. Fifteen propositions are claimed by Ghulam Husain to be his own discovery.

## S.m.4. JACOB K. DANIEL–Queueing and Inventory Models with Rest Periods–1985–Dr. A. Krishnamoorthy

In this thesis some queueing and inventory problems with vacation to the server are considered. This is the first work which introduces vacation in an inventory.

In the queueing problems considered stationary solution is obtained using the matrix geometric method. The waiting time distribution is also discussed. The following are the models discussed:

### (I) GI/M/1 Queue with rest periods

The interarrival times are i.i.d.r.vs. having a general distribution and service times have eponential distribution. The server goes on vacation either after serving k units without any break in between services or when the system becomes empty, whichever occurs first. The vacation times are i.i.d. exponential variates and are independent of the arrival and service processes. After a vacation if the system is found empty the server remains idle. Observing the system at epochs just prior to arrival points, one can get a Markov chain (two dimensional; one component indicating the servers position (idle or vacation) the other indicating the number of units in the system. If the server is serving then the first component stands for the number in the system and the second indicates the number of units served after the previous vacation. This Markov chain is analysed and its stationary distribution obtained. Also the waiting time distribution is computed. The particular case of an M/M/1 queue with vacation is discussed in detail and an optimal control problem solved.

### (II) $M/M^{a,b}/1$ queue with vacation

Here the arrival process is a Poisson process. Service times are in batches of size taking values a, a+1,......b and this depends on the number in the system. ie., if more than b units are in the system the first b are taken for service. Otherwise all are served simultaneously. The service times have exponential distribution with parameter depending on the number ot units in the batch undergoing service. If the number waiting for service is less than a, at a service completion point the server goes for vacation having an exponential distribution. On return again if the system size is found to be less than a then he remains idle. Here again a two dimensional Markov chain is identified and its limiting stationary distribution obtained.

### (III) $M/E_k/1$ queueing system with feedback and vacation

The service tmes are Erlang of order k. After serving m units consecutively the server goes on vacation of an exponentially distributed duration. The served unit feedback to the system with probability $\theta$, $(0 < \theta < 1)$ immediately after service. A three dimensional Markov chain is identified and its steady state probability determined.

Also considered is two queues in series, with an intermediate waiting room having finite capacity. The service times with the first and second servers have exponential distributions. The first server goes on vacation when the intermediate waiting room is full or whenever there is none wating to be served by him. He remains idle on return from vacation if either the intermediate waiting room is full or there is none in the first queue. A four-dimensional Markov chain is identified and its limiting behaviour studied. The condition for the existence of steady state is also derived. Finally some numerical examples are given.

In Inventory three problems are investigated. Their time dependent behaviour alone is looked at. It is difficult (or rather impossible to get the stationary behaviour via the present approach).

The arrival of demands constitute renewal process. The lead times are i.i.d.r.vs. having a general distribution. The policy adopted is of the (s,S) type. The models discussed are:

(i) no queue of demands is permitted when the server is on vacation

(ii) a queue of demand is permitted when the server takes rest, but only after the replacement of stock.

(iii) Two servers $S_1$ and $S_2$ with rest periods alternately to the servers.

The vacation times are i.i.d. random variables having a general distribution. The vacation is not extended and the server remains idle if the replenishment has not taken place on return from vacation. The system size probabilities are obtained.

## S.m.5. THRESIAMMA, T.K.–Discrete Commutative Difference Operator Theory–1986–Dr. Wazir Hasan Abdi and Dr. T. Thrivikraman.

This thesis is an attempt to study basic and bibasic commutative difference operators on the lines of J.L. Burchnall and T.W. Chaundy's "Commutative differential operators" and on the discrete sets $\{p^m x_o\}$, $\{q^n y_o\}$, $\{q^m x_o, q^n y_o\}$, $\{q^m x_o, q^n y_o\}$, $\{p^m x_o, q^n y_o\}$, $\{q^m x_o, p^n y_o\}$ $m, n \in Z$, where p,q are positive real constants called bases, p = q = 1. Also bibasic pseudo-analytic functions are introduced using two bases p and q.

Though commutative differential operators play an important role in analysis, no basic or bibasic theory is available. This thesis is an attempt in this direction.

In the first chapter an outline of the theory of commutative differential operators done by Burchnall and Chaundy in the classical case is given. A historical survey of the study of q-difference equations, q-analytic function theory of C.J. Harman (1972), bibasic analytic functions of Khan, M.A., bianalytic functions of K.K. Velukutty (1982), Discrete Pseudoanalytic functions of Mercy K. Jacob (1983) and the recent works already done by others have been stated. A list of the results established in the thesis is also given.

The second chapter deals with definitions of basic difference operators, characteristic identity of two commutative basic difference operators and the specific nature of commutative difference operators. If

$P_m = \ a_k\theta^k$

$Q_n = \ b_k\theta^k$

then it is proved that if $a_k$ and $b_k$ are constants or q-periodic functions of x then $P_m$ and $Q_n$ are commutative. But if they are variable functions of x they are commutative. Hence the conditions for which these commute are obtained. It is observed that there are some relationships between the coefficients $a_k(x)$ and $b_k(x)$ which make the operators commute with each other. Some examples are constructed. Then it is proved that the difference operators P and Q are commutative if and only if $F(P,Q)=O$.

Some special commutative operators are developed in the third chapter. Taking $\omega = x\theta$, $\theta^n$ is factorised by means of $\omega$. If two operators have a common factor, by transference of that factor we obtain new operators. And it is shown that if P' and Q' are the new operators obtained by transference of common factor of P and Q respectively then $F(P,Q) = F(P', Q')$. The result $f(\omega)x^a = f([a])x^a$ is derived, and the inverse $f^{-1}(\omega)x^a = f(1\,\omega\,[a])\,x^a$ is found. Using these results some q-difference equations are solved.

In the fourth chapter basic adjoint operators are defined and their properties are listed. If P and Q are commutative, their adjoint also are commutative. The same results are obtained for transference also. Then it is shown that if a linear operator commutes with an operator P, it is a polynomial in that operator.

The bibasic commutative difference operator are studied by considering functions of x and y in $R^2$. Definition of $D_{px}$ and $D_{qy}$ with bases p and q and their properties studied in the fifth chapter. Some special bibasic commutative difference operators are taken and some bibasic difference equations are solved.

The last chapter deals with bibasic pseudoanalytic functions and their properties. Pseudoanalytic functions of Mercy, bibasic analyic functions of Khan, bianalytic functions of K.K. Velukutty, and q-analytic functions of Harman are special cases of this. Bibasic analogues of $Z^{(n)}$ and exp b(z) of classical power and exponential functions etc. are also given as examples of such functions.

## S.m.6. VIJAYAKUMAR–A. Studies in the Geometry of the Discrete Plane–1986–Dr. Wazir Hasan Abdi and Dr. T. Thrivikraman.

In this thesis, an attempt is made to study some geometric properties of the discrete plane $H = \{(q^m x_o, q^n y_o);\ m,n \in Z$, the set of integers$\}$ where $(x_o, y_o)$ is a fixed point in the first quadrant of the complex plane, $x_o = o$, $y_o = o$, and $q \in (o,1)$ is fixed. This discrete plane was first considered by C. Harman (1972) to develop the theory of q-analytic functions. The theory was a consequence of attempt made by Isaacs, Duffin, Abdullaev etc. since 1941, to evolve a discrete analytic function theory analogous to the classical complex analytic function theory. These theories are free from the classical notion of continuity. Recently, concepts like discrete bianalytic functions, q-monodiffric functions (Velukutty, K.K., 1982) and discrete pseudo-analytic functions (Mercy K. Jacob, 1983) have been introduced and studied in detail. All such theories are function theoretic in nature.

In this thesis, the notion of a metric on H, discrete analogues of some classical geometric concepts, transformations on H, characterization of certain special types of transformations, group theoretic and discrete analytic properties of these transformations, discreate analogue of convexity and related concepts are introduced and investigated. This study, hence will initiate the development of discrete geometry of H.

In chapter 1, the basic principle of discretization, a sketch of the development of discrete analytic function theory, a brief description of geometry of a space and also the summary of results established in this thesis are given.

In chapter 2, using the concept of discrete curve given by Harman, the distance between any two points of H is defined. The distance functiond assumes non negative integral values and (H,d) is called the discrete holometric space. The notion of domain in H is defined and a metric characterization of it is obtained. Also, bounds for the diameter of any domain are obtained.

Not considered in this chapter are the discrete analogues of segments and circles which are termed, D-linear sets and r-sets respectively. It is proved that the intersection of two D-linear sets is also D-linear, but not the union. A necessary and sufficient condition for a subset of H to be D-linear is obtained. For r-sets, formulae for the number of points on it and in its interior are found. After defining the notions of contact set, interseciton, discrete annulus etc. for two r-sets, some results are established. Some contrasts with the Euclidean case are brought out. the intersection of discrete Pythagorean type in analogy with the orthogonal intersection of circles are then considered and some properties are obtained.

One of the most important concepts in the development of any geometry is that of a transformation. In chapter 3, bijective mappings of H onto itself called D-transofrmations are introduced. Special transformations like D-translation and D-isometry are defined and studied. Some results obtained seem to be interesting, to mention one, D-isometries map domains onto domains. D-linear transformations are defined and characterized.

The D-transformations that take r-sets onto r-sets have also been studied in detail. In this case, the transformations between r-sets of equal radii only need be considered in order to maintain the bijective nature of the D-transformation. It is found that these special type of transformations form a finite, non abelian, solvable, nilpotent group. In the last section of this chapter, discrete analyticity properties of these transformations have been investigated. The geometry developed here, could be used in the analysis done by earlier authors like Harman. The guidelines are provided in this section.

The notion of convexity outside the framework of linear spaces, has been extensively studied. In the first two sections of chapter 4, we define D-cenvexity for subsets of H and obtain a sufficient condition for a domain to be not D-convex. Also. concepts like D-kernel and D-convex hull are considered and some characterization theorems are obtained.

In the next section, some results obtained in the course of the investigation, which are interesting, although not directly along the main line of thought in the thesis, are presented. These include, a matrix representation of domains, the entries of the matrix being the distance between points of it, and the notion of metric content for subsets of H, which is the sum of elements in the upper (lower) triangular part of the distance matrix associated with the subset. The notion of E-set analogous to the ellipse is also considered.

## S.m.7. RAMACHANDRAN, P.T.–Some problems in set topology relating group of Homeomorphisms and order–1986–Dr. T. Thrivikraman

In this thesis, some problems in set topology, related to the concepts of group of homeomorphisms and order are investigated. Order theoretic methods are extensively used to investigate problems which are directly or indirectly related to the concepts of group of homeomorphisms of a topological space onto itself.

De Groot (1959) proved that any group is isomorphic to the group of homeomorphisms of a topological space. A related problem is to determine the subgroups of the group of permutations of a fixed set X, which can be represented as the group of homeomorphisms of a topological space (X,T) for some topology T on X. In chapter I of this thesis, some results along this direction are given. These include the result that no nontrivial proper normal subgroup of the group of permutations of a fixed set X can be represented as the group of homeomorphisms of a topological space (X,T) for some topology T on X.

Homogeneity and rigidity are two topological properties closely related to the group of homeomorphisms. Bankston, P defined (1979) an antiproperty for any topological property and discussed the antiproperties of compactness, Lindelofness, sequential compactness and so on. Reilly, I.L. and Vamanamurthy M.K. (1980) and (1981) obtained the antiproperties of separation axioms and compactness properties. In chapter III of this thesis, anti-homogeneous spaces are investigated and several characterisations are given. In particular it is proved that a space is antihomogeneous if and only if it is hereditarily rigid. The study is based on a pre-order associated with a topology (studied earlier by A.K. Steiner (1965), Lorran, F(1969), S.J. Andima and Thron W.J. (1978). The notions of homogeneity, anti-homogeneity and rigidity are introduced for preordered sets also. It is proved that a topological space is anti-homogeneous if and only if the associated preordered set is anti-homogeneous. A structure theorem for semi-well ordered sets (ie. linearly ordered sets in which every nonempty subset has either a first element or a last element) is the main order theoretic tool established and used.

Chapter 3 deals with the Cech closure spaces. Here an attempt is made to extend some results of the first two chapters to Cech closure speces. These include the characterisation of completely homogeneous spaces and results related to the pre-ordeer associated with a topology.

In chapter 4, investigation is done on the lattice of closure operators on a fixed set X, with special attention to complementation. The atoms and the dual atoms of the lattice are determined first. The complementation problem is solved in the negative, using this. The lattice is dually atomic, but no element in it has more than one complement. Finally, some sublattices of this lattice and the fixed points of the automorphisms of this lattice are discussed.

## S.m.8. JESSY JOHN, C.–ARMA Modelling of time series based on rational approximation of spectral density function–1987–Dr. R.N. Pillai

A new technique for ARMA (p,q) model selection using rational approximation of spectral density function is presented in this thesis. The thesis is divided into seven chapters.

In the first chapter a brief historical survey of stationary time series and summary of the new technique is given. Yule (1927) introduced the notion of autoregressive models. He was followed by Wold (1954). The works of Akaike, H. (1962) for fitting autoregressive models, Brown R.C. (1962) for fitting models by exponential smoothing, Box G.E.P. and Jenkins, G.M. (1970) for ARMA (p,q) model fitting, McIntire, D.D. (1977) for ARMA (p,q) model identification of time series and other recent developments in the area are discussed. The second half of this chapter contains the summary of the new model identification technique presented in this tesis.

Notations and definitions are given in chapter two. Stationary time series, autocorrelations and partial auto-corrilations of a stationary time series, difference operator, ARMA (p,q) models, ARIMA (p,d,q) models, etc. are defined. Different forms of the spectral density functions of a stationary time series are discussed.

The third chapter explains the new model identification technique. A unique ARMA (p,q) model representing a given stationary time series is obtained. Rational approximations of functions are discussed first. The theory of rational approximation due to Chebyshev (1962), is applied here. Applying this theory a unique rational approximation of the spectral density function is obtained.

An algorithm is developed to solve the nonlinear equations based on iteration. These p+q+1 parameters uniquely determine the ARMA (p,q) model for a given stationary time series.

In the first part of chapter four, the new model building procedure is tested using theoretical autocorrelations for ten different ARMA (p,q) models. It is found that the error between the theoretical values of the parameters and the estimated values of the parameters are very small proving the efficiency of the new technique for ARMA model estimation. In the second part of chapter four the new technique is applied to analyse simulated series and in the third part it is applied to original time series data. It is found that the new model identification procedure is highly suitable.

The fifth chapter gives some results in connection wiht the new ARMA model building technique. It is shown that the relation between the autocorrelations and the parameters in ARMA (p,q) model are same as that given by Box and Jenkins. Multivariate extension of the procedure is taken up for two variables.

Comparison of the new method for ARMA (p,q) model identification with some prominent methods like Box-Jenkin's method, McIntire's method are given in chapter six. It shows that this new technique gives a unique ARMA (p,q) model for a given stationary time series, whereas the other method gives different models for the same series.

In the concluding chapter, a brief discussion on the new technique for identifying ARMA (p,q) model representing a stationary time series is given.

## S.m.9. Ramachandran Nair, V.K.–Queueing Models with rest to the server after serving a random number of units–1988–Dr. A. Krishnamurthy

Queues with rest to the server were analyzed by several authors. The doctoral thesis of Miller (1964) is concerned with an M/G/1 queue with rest to the server. The doctoral thesis of Jacob K. Daniel (1985) also treats some queueing models with vacation to the server; instead of exhaustive service, he assumes that the server takes rest either after serving k consecutive units or whenever the system becomes empty, whichever occurs first.

In this thesis Miller's and Daniel's results are generalised by assuming that the server goes on vacation after serving a random number of units. In all the models discussed in this thesis the rest times of servers are assumed to be i.i.d exponential variates which are further independent of the arrival and service processes. The number of units served between consecutive rests takes values from 1 to m (finite and fixed). The probability of taking vacation after serving the $k^{th}$ unit is $p_k$. k = 1,2........, m with $p_0 = 0$ and, of course $p_m = 1$. In most of the cases the condition for existence of steady state is explicitly obtained. Wherever it is impossible to find, sufficient conditions are given for the existence of steady state. For the first time in the literature, queue with vacation is introduced for a multiserver queue.

Chapter II concentrates on the simplest type of queueing model - the arrival is according to a homogeneous Poisson Process, service times are i.i.d exponential variates. In addition to the usual assumption it is assumed that each unit instantaneously feedsback with probability $\theta$ ( $0 < \theta < 1$) after being served. The stability condition for the system is obtained, steady state probability distribution of the system is computed, and the waiting time distribution of a unit in the system (here defined as the total time spent in the system until served satisfactorily) by considering a bivariate Markov process, is derived. The situation where the server goes for rest either after serving k consecutive units or whenever the system becomes empty, whichever occurs first, is also discussed.

In Chapter III, a queueing problem in which inter arrival times of customers are i.i.d random variables following some arbitrary distribution is considered. Service times of units are i.i.d exponential variates and are independent of the arrival process. Using the embedding techniques, a bivariate Markov process is constructed. The associated transition probability matrix is obtained. Using this the steady state behaviour of the system and the necessary and sufficient condition for its existence are obtained. The waiting time distribution of a unit in queue is given. An optimization problem associated with the model is discussed.

In the IV chapter the assumption of exponentially distributed service times is dropped. Instead, service times are taken as i.i.d gamma variates of order k. The arrival process forms a homogeneous Poisson Process. Here again a bivariate Markov process is constructed and its steady state probability distribution studied. The condition for the stability of the process is derived. The waiting time distribution of a unit in the queue in the steady state is also given.

In chapter V a bulk service queueing model is considered, in which the arrival process is a homogeneous Poisson process. The size of each batch taken for service lies between c and d. The server goes for rest after serving a random number of batches (atleast one and atmost m(fixed)). A bivariate Markov process to analyse the problem is studied. A sufficient condition for the stability of the process is given. Also the waiting time distribution of a unit in the queue in the steady state is derived. Finally some results are given for the above model with interarrival times being i.i.d. random variables having arbitrary distribution.

The VI chapter is about a queueing problem with S servers. The arrival to the system is according to a homogeneous Poisson process. Service times are i.i.d. exponential variates. A unit is served by a single server. Initially all servers are available. After serving a unit if there is no unit waiting in the queue the server goes for rest of random duration. No server goes for rest without serving atleast one unit. The rest times of servers are i.i.d exponential variates. If on return after rest, the server finds no unit waiting in the queue he remains idle. Again this system is studied by considering a bivariate Markov process. The steady state distribution of the system is indicated and waiting time of a unit in the queue is derived.

In the VII chapter a buffer model is considered. The system consists of two servers in series and a finite intermediate waiting room between them. The arrival is according to a Poisson process and the first server remains idle either when the first waiting room is empty or when the second waiting room is full. The second server goes for rest of exponentially distributed duration after serving a random number of units (atleast one and atmost m, where without loss of generality we may also assume m to be the capacity of the second waiting room). The steady state behaviour of this model is investigated and waiting time distribution is found out.

## S.m.10. JACOB, M.J.–Probabilistic Analysis of Some Queuing and Inventory Models–1988–Dr. A. Krishnamoorthy

This thesis considers a number of models in Queues and Inventories. The (s,S) policy is followed for the inventory problems.

The interarrival time between demands are assumed to be i.i.d.r.vs following a general distribution. Lead times are also i.i.d. independent of the demand process. The server goes on vacation if the inventory becomes dry. All demands that arise during the server vacation are lost. The inventory level deistributions, are obtained. This is modified to allow an agent supplying S-i units of the item when inventory level is, $\theta < i \leq s$. When inventory becomes dry server goes on vacation. The server on return allows a maximum number S-s-1 demands to queue up, if the replenishment has not yet taken place. Both the system size probabilities and queue size probabilities are computed. Yet another modification considered is local purchase of the item at an extra cost, if the item is available, as soon as inventory size becomes zero. Otherwise server goes on vacation. Here again the system size probabilities are computed.

The correlation between lead time and dry period for inventory is established in the case when both interarrival times and lead times are assumed to have exponential distribution.

An inventory problem with compound renewal demand is another model that is considered. the lead times are i.i.d.r.vs independent of the demand process. Convolution of matrices whose entries are probabilities is used to calculate the system size probabilities.

Yet another inventory model discussed is the following. The ordering levels vary according to the number of demands that occur during the previous lead time. The lead times and interarrival times between demands are assumed to be independent sequences of i.i.d.r.vs. Expressions for the stock level distribution and the corrleation between the number of demands during a lead time and the next inventory dry period are obtained. This again is done using the convolution of matrices whose entries are probabilities.

The following queueing models are analysed.

Units arrive to a single server system according to a general rule. Services are in batches of size atleast 'a' and atmost 'b'. Service times are exponentially distributed and depends on the size of the batch being served. If the number of units waiting in the queue at a service termination point is found to be less than a, then the server goes on vacation of duration having exponential distribution. If on return the queue size is less than a then the server remains idle until the queue size accumulates to a. A two dimensional Markov chain is embedded in the continuous time process representing the number of units undergoing service or the servers condition such as idle or on vacation as one of the coordinates and number in the queue as ther other co-ordinate. The steady state probability distribution is computed using the matrix-geometric method. The waiting time distribution of an arriving unit is also computed.

Another problem that is attempted is the computation of time dependent probability distribution of the system size in a finite capacity queue. The arrival process is Poisson. Service times have arbitrary distribution. The server goes on vacation of a random duration whenever the number waiting at a service completion point is less than the minimum batch size 'a' to start service. The vacation rule is of the multiple type. Using convolution of matrices of probabilties, the system size probabilities are obtained. The virtual waiting time is also computed. As a particular case the single service situation is also discussed.

## S.m.11. NIRMALA ANTHERJANAM, N.–Studies on Korteweg-De Vries Equations–1988–Dr. M. Jathavedan

The korteweg-de Vries (KdV) equation is one the most widely studied evolution equations in non-linear waves, which was derived in the last century by Korteweg and de Vries as a model equation for nonlinear dispersive long waves (1895). The most outstanding property of this equation is that is admits solitary waves, first reportedd by J.S. Russell (1845) as solutions. The interest in the study of KdV equation was revived after a numerical expriment by Sabusky and Kruskal in 1965. They found that two solitary waves after interaction emerge unchanged but for a phase shift. Since then KdV equation has found application in different fields like gravity waves, plasma waves and waves in lattices.

The thesis deals with studies on KdV equations. Chapter 1 is introductory. It contains a brief account of nonlinear hyperbolic waves, dispersive waves and the KdV equation in the context of water waves.

R.S. Johnson has found (1973) that the propagation of waves on shallow water, when the depth changes abruptly forming a shelf, is given by a KdV equation, the coefficients being functions of the far field space coordinate. In Chapter II we study the interaction of waves given by this equation. The derivative expansion method is applied. It is seen that three waves interaction is possible and there is exchange of energy between different wave numbers. The total energy is not conserved during interaction.

Johnson's equation is only a special case of the general form of KdV equation. There are many other KdV type equations arising in different contexts. In chapter III we give an account of these. We introduce a KdV type equation with variable coefficients. In the remaining chapters we study this equation.

The test of integrability is an important branch of study of nonlinear evolution equations. The Painleve Property (PP) is known to be related to the integrability of ordinary differential equations. In recent years the Painleve analysis has been extended to the study of partial differential equations also. In Chapter-IV we study the integrability of the above KdV equation using the method proposed by J. Weiss, M. Tabor and G. Carnevali (1983). The auto-Backlund transformation and Lax pairs are obtained by this method. Lax pair criterion enables to find the cases in which the equation is integrable.

In many cases when a differential equation cannot be integrated we can study the properties by qualitative methods. Similarity analysis is one such qualitative method which can give valuable informations regarding the solutions without solving the equation completely. Chapter-V is devoted to a similarity analysis of the KdV equation. The Ablowitz-Ramani-Segur (ARS) conjecture is used to identify the integrability of the equation. It is found that in some special cases the equation may be integrable. The exact solution in a particular case is obtained.

The Weiss et al. analysis is not a fully satisfactory method for testing the integrability and it is known that the method may lead to incorrect conclusions, atleast in some cases. But when a non-autonomous KdV system is integrable it can be transformed into an autonomous integrable KdV system by a suitable transformation. In the last chapter it is shown that the two cases in which the equation is integrable, it can be transformed into the plane KdV or cylindrical KdV equations. Since the integrability of the equation in these two cases is already known it follows that the method of Weiss et al. leads to correct conclusions in the case of this equation.

## S.m.12. MATHEW, P.M.–On the Lattice of Topologies and Boolean Spaces–1988.–Dr. T. Thrivikraman

Correspondence between order and topology was investigated by several mathematicians in different contexts—G. Birkhoff (1936) and R. Vaidyanathaswamy (1960) being the forerunners.

In this thesis, the study is on the relation between topology and order in the following contexts.

i) Relation between some known order properties and topological concepts—determination of maximal and minimal topologies having those properties.

ii) Order theoretic aspects of the lattice of all topologies on a set.

iii) Studies on some classes of ideals in a Boolean ring on order theoretic terms and their topological interpretation using Stone representation theorem.

Andima S.J and Thron W.J. defined (1978) a space upward directed if any two elements in the basic set has an upper bound under the induced order and characterised maximal upward directed toplogies order theoretically. In Chapter 1 of this thesis, the equivalence of the notions of ultraconnected and upward directed is indicated and the property-downward directed is discussed and its equivalence to hyperconnectedness among principal topologies is established.

Aslo an internal characterisation of hyperconnected spaces using semi-topological concepts is established and the result of T. Noiri (1980) that hyperconnectedness is a semi-topological property is derived as a corollary. Maximal hyperconnected topologies are characterised and it is shown that hyperconnected door topologies are maximal hyperconnected and minimal door. Further, maximal ultraconnected topologies on a set are determined and it is shown that ultraconnected $T_{1/2}$ topologies are maximal ultraconnected and minimal $T_{1/2}$.

Chapter 2 is a study of F-connected spaces, spaces which are hyperconnected and ultraconnected. F-connectedness is shown to be not hereditary not productive and not semitopological. The maximal compact F-connected topologies are determined. It is noted that any dual atom in the lattice of topologies is the least upper bound of two minimal door topologies of which one is maximal ultraconnected and the other maximal hyperconnected.

In chapter 3, a study of the concept of covers in the lattice L(X) of all topologies on a set X is presented. Also a discussion of this concept in the system of closure relations is undertaken. A method to construct a completely regular topology coarser than a given topology which is the unique completely regular topology covered by the original topology characteristic for preservation of continuous maps is also given in this chapter.

An immediate consequence of Stone representation theorem is that the Boolean algebra of regular open sub-sets of a compact Hausdorff, O-dimensional space is a completion of its clopen subsets. In chapter 4, it is shown that the Boolean algebra of normal ideals in a Boolean ring is a minimal completion of the algebra of its semiprincipal ideals, which is an extension of the above result to the case of Boolean rings. Further a natural limit to the applicability of Stone's theorem is indicated.

### S.m.13. SUNANDAKUMARI, V.M.–Theory of differential inequalities with applications to singular perturbation problems and method of lines–1989–Dr. N. Ramanujam

During recent years, the theory of differential inequalities has been extensively used to discuss singular perturbation problems and method of lines to partial differential equations. The present thesis deals with some differential inequality theorems and their aplications to singularly perturbed initial value problems, boundary value problems for ordinary differential equations in Banach space and initial boundary value problems for parabolic differential equations. The method of lines to parabolic and elliptic differential equations are also dealt with.

The thesis is organised into nine chapters. A detailed description of chapters would run as follows:

The first chapter reviews briefly the earlier developments of the theories in the field related to the current work and also discusses the scope of this thesis.

In the second chapter the background material, mainly differential inequality theorems or monotonicity theorems, which shall be needed in the subsequent chapters is presented.

The third chapter is devoted to study the asymptotic behavious of solutions and/or their derivatives of the following boundary value problems for weakly coupled doubly infinite systems of second order ordinary differential equations with a small parameter multiplying the highest dervative. The boundary value problems are the infinite system of differential equations.

$P\,u: -\epsilon u'' + f\,(t, [u]', u, \epsilon) = 0,$

that is

$P_i u' - \epsilon u_i'' + f_i\,(t, u_i', u, \epsilon) = 0, t, \epsilon D: = (a,b),\ i \epsilon Z$

subject to any one of the following boundary conditions

$R\,u: = (u\,(a,\epsilon),\ u(b,\epsilon))^T = (A(\epsilon),\ B\epsilon))^T,$

$R\,u: = (u\,(a,\epsilon),\ u'(b,\epsilon))^T = (A(\epsilon),\ B\epsilon))^T,$

$R\,u: = (u\,(a,\epsilon),\ \epsilon u'(a,\epsilon),\ u'(b,\epsilon)^T = (A(\epsilon),\ B\epsilon))^T,$

where $u = (\ldots, u_{-1}, u_0, u_1, \ldots)^T$

$A(\epsilon) = (\ldots, A_{-1}(\epsilon),\ A_0\,(\epsilon),\ A_1(\epsilon), \ldots)^T$

$B(\epsilon) = (\ldots, B_{-1}(\epsilon),\ B_0\,(\epsilon),\ B_1(\epsilon), \ldots)^T$

$\epsilon$ is a small positive parameter such that $0 < \epsilon \leqslant \epsilon_1'$

T stands for the transpose, Z is the set of all integers, and a prime denotes a differentiation with respect to t. The study is carried out by first obtaining necessary estimates using monotonicity theorems for solutions and/or their derivatives of the above boundary value problems. In turn, these estimates determine the asymptotic behaviour of solutions and/or their derivatives as the small parameter approaches zero.

The results of the third chapter are extended in the fourth chapter for the differential equations obtained by replacing b by $\infty$.

Chapter 5 deals with certain initial value problems. First the asymptotic study, as the parameter $\epsilon$ goes to zero, is carried out for the linear equations of the form.

$\epsilon x'' + \propto x' + \beta x = r\ ,\ \propto\ = \propto(t,\epsilon),\ \beta = \beta\ (t,\epsilon)$

$r = r(t,\epsilon)$

and then the results are generalized to the nonlinear systems. Using monotonicity theorems, asymptotic estimates for solutions are constructed, under appropriate assumptions, in terms of solutions of the corresponding reduced problems.

Chapter 6 treats linear and nonlinear parabolic differential equations with a small parameter multiplying the time derivative. More precisely, the differential equations subject to Dirichlet type boundary conditions are considered. Guided by the experience with ordinary differential equations and using parabolic differential inequality theorems, estimates for solutions of the present problems are obtained. In turn, these estimates determine the asymptotoc behaviour of solutions as the small parameter $\epsilon$ approaches zero.

In Chapter 7 an attempt is made to study the method of lines ( a special case of differential-difference scheme) when applied to nonlinear elliptic differential equations defined on a unit square and semi infinite strip. In fact, a few results are presented on the error estimates and the convergence of the the method of lines to certain boundary value problems. Due to the presence of the small parameter $\epsilon$, a modified version of the existing difference scheme is suggested. Using the second order differential inequalities theory, error estimates and hence the convergence of the method of lines are obtained.

The method of lines, more precisely longitudinal line method, for some problems is discussed in Chapter 8.

The last chapter continues with the study of the method of lines begun in Chapter 7. In this chapter a weakly coupled system of two parabolic differential euations with a small parameter multiplying the highest spatial derivatives is considered and results similar to that given in Chapter 8 are given.

## S.m.14. MADHUSOODAN, T.P.–Time dependent solutions for some queueing and inventory models–1989–
## Dr. A. Krishnamoorthy

In this thesis we study the time dependent behaviour of some complex queueing and inventory models. In our analysis-renewal theory plays an important role. In each model, identifying the regeneration points and using matrix convolutions, we obtain the required transition probability densities.

The thesis is divided into seven chapters and the first chapter gives a brief introduction to the subject matter and some related topics. In the second chapter we consider a finite capacity bulk service queueing system. The arrival of customers is according to a homogeneous Poisson process and the service times are generally distributed independent random variables and the distribution is depending on the size of the batch being served (ie. $M/G^{a,b}/1$ System). Using renewal theoretic arguments, we derive the probability distribution of the busy period and the time dependent system size probabilities at arbitrary epochs. Also we derive the probability distribution for the virtual waiting time in the queue at any time t.

Next chapter delas with an infinite capacity $M^X/G/1$ queueing system with vacations to the server. Under exhaustive service discipline, server takes vacations for a random duration having general distribution following multiple vacation rule. Here also we derive the time dependent system size probabilities at arbitrary epochs and the probability distribution of the virtual waiting time.

A finite capacity $M/G^{a,b}/1$ queueing system with vacations to the server is analysed in chapter four. The general bulk service rule is modified to allow the arriving customers to enter for service. Arriving customers enter for partial service with probability p and wait for full service with probability 1-p, till the service capacity is attained. Server goes for vacation whenever there are less than 'a' customers in the system and this is a multiple vacation. The time dependent system size probabilities and the probability distribution of virtual waiting time are derived explicity.

In chapter five, a finite capacity $M/G^B/1$ vacation system with Bernoulli schedules is analysed. After each service completion server starts a new service, if customers are present, with probability p and takes a vacation with probability 1-p. If the system is empty at a service completion point or vacation completion point, server always takes vacation. At vacation completion points, if there is at least one customer server resumes service. Here also we derive explicit expressions for the time dependent system size probabilities and the probability distribution of the virtual waiting time.

In the next two chapters we analyse some single item continuous review (s,S) inventory systems with rendom lead times. In chapter six, we study an inventory system in which the quantity replenished is a random variable. The inter arrival time of unit demands and lead times are inedpendent sequences of i.i.d. random variables following general distribution. Order is placed at level s for S-s units and the quantity replenished is a random variable that can assume values s+1,...,S-s. We derive explicit expressions for the probability mass function fo the stock level at arbitrary epochs. An expression for the total cost over a period of time is obtained. Then we consider the special case of zero lead time and discuss the associated optimization problem in detail.

In the last chapter, we consider an (s,S) inventory system with random lead time depending on the size of the order. The time between successive demands and the quantities demanded at these points are independent sequences of i.i.d. random variables following general distribution. Whenever the inventory level falls to zero, the server goes for vacation for a random duration following a general distribution. Using renewal theoretic arguments, we derive explicit expressions for the inventory level probabilities at arbitrary epochs. Some directions for further work are given in the last section.

## S.m.15. MERCY MANI, P.–Studies on nonlinear dynamics of certain reaction system–1989–Dr. M. Ramachandra Kaimal

The nonlinear dynamics of certain important reaction systems are discussed and analysed in this thesis. The interest in the theoretical and the experimental studies of chemical reactions showing oscillatory dynamics and associated properties is increasing very rapidly. Many researchers work out mathematical models of such reactions to understand the complex nature of the systems. The oscillatory behaviour and other related characteristics in nonlinear systems far from equilibrium has a highly interesting connection with the organization of the structure of the system.

An attempt is made to study some nonlinear phenomena exhibited by the well known chemical os cillator, the Belousov-Zhabotinskii reaction whose mathematical properties are much in common with the properties of biological oscillators. While extremely complex, this reaction is still much simpler than biological systems atleast from the modeling point of view. A suitable model (Field and Noyes, 1974) for the system is analysed and we have studied the limit cycle behaviour of the system, for different values of the stoichiome tric parameter f by keeping the value of the reaction rate ($k_6$) fixed at $k_6=1$. The more complicated three-dimensional model is stiff in nature. The values of the parameters in the system other than f viz. s, w and q are fixed as 77.27, 0.161 and $8.375 \times 10^{-6}$ The existence of limit cycle behaviour in the three dimensional model is shown analytically and are verified numerically. Among many numerical methods to solve such systems of monlinear differential equations the Runge-Kutta method with step doubling is found to be the most suitable one to solve our system. Limit cycle behaviour is observed for the complete model in the y–x phase plane for f=1.0 and f=1.1, with periods t=143.5 and t=148.9 respectively.

The two variable (y-z) model, being much easier to handle mathematically is examined more thoroughly. The oscillatory behaviour of this system is examined for several values of f lying in the unstable region $1/2 < f < 1+\sqrt{2}$. Isolated limit cycles are obtained for f = 0.5001, 0.74, 0.9 1.0, 1.3, 1.4 and 1.5 in the y-z plane. The birth of more than one limit cycle is observed for the system at the parametric values f=1.1, 1.2 and 1.595288. This may be considered as s signal for the excitability property of the reaction model. Many workers [N.F. Britton (1982), G.B. Ermentrout and N. Kopell (1986)] predicted and some discussed the excitable behaviour of B-Z reaction system for this range of f.

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The solution trajectory starting from the initial concentration $(y_0, z_0) = (1.0, 488.8)$ is attracted to another stationary state (1.297, 4.355) for some parametric values f=1.6, 1.7, 1.8, 1.9, 2.0, 2.1 etc. The multiple steady states are observed in this region of f.

The fact that the autocatalysis is the common feature of almost all oscillators (biological and non-biological) inspired us to study a general cubic autocatalytic system.

We have presented a model analysing the auto catalytic system. The cubic autocatalytic step $A+2B \rightarrow 3B$ lies at the heart of the simplest models for oscillatory and other complex nonlinear behaviour in closed systems, in the C.S.T.R. and in reaction coupled with diffusion. General reaction systems containing either quadratic auto catalytic reaction step or cubic autocatalytic step, coupled with autocatalyst decay step which are two dimensional were studied so far. In order to explain the complex phenomena observed in oscillators like aperiodic oscillation, period doubling etc. a three dimensional model is required. Sustained oscillatory behaviour is observed in the system. The range of the controlling parameter K at which the stationary states are unstable is found analytically. This range is found to be $K_{1c} < K < K_{2c}$ where $K_{1c} = 0$ and $K_{2c} = 0.0003$. The values of the other parametric values n' and $t_2$ are fixed as $n' = 10^{-4}$, and $t_2 = 10^4$. The initial value taken for the numerical integration is $x_0=Y_0=Z_0=0.1$. Limit cycles are obtained for the system in X-Y, Y-Z and Z-X phase planes respectively. The trajectories are attracted to a limit cycle and the unstable critical point inside it acts as an attractor, for the supercritical Hopf bifurcation point $K_{2c}$. When the integration of the system is carried out numerically for other parametric values less than $K = 0.0003$, large amplitude waves corresponding to the concentrations of each constitutents P,A and B are formed. The trajectories corresponding to the system repel from a fixed point $(3\times10^{-4}, 8\times10^{-6}, 3\times10^{-4})$. Thus the numerical result confirms the analytic preduction that the equilibrium state solution of the system in the region $K_{1c} < K < K_{2c}$ is an unstable focus. At the critical Hopf bifurcation value $K_{2c} = 0.0003$, the unstable focus becomes a stable one. The same behaviour of the solutions described above are obtained for some other values of $t_2$, viz. 9999.0, 10001.0, 10002.0, 10003, 10004.0, 10005.0, 10007.0, 10008.0 and 10009.0.

Several interesting phenomena, other than sustained oscillations or damped oscillations, such as bursting, excitability, intermittency, CDO, Chaotic structures etc. are to be examined more elaborately for the oscillators, considered here. In the case of the three-variable Oregonator model, the sustained oscillatory behaviour of the system is to be examined for all other values of f. Satisfactory models are yet to be developed for explaining some recent experimental results of the B-Z chemical reaction (eg. certain pattern formation). The reaction system based on the cubic autocatalytic step has to be subjected to more studies.

## S.m.16. PRAMOOD, K.V.–Numerical and analytical studies of some problems of water waves–1989–Dr. M. Jathavedan

One of the most interesting and successful application of hydrodynamical theory is to the study of wave propagation on water surface. Over the last one century the theory was further developed to study more complex phenomena associated with wave propagation. Thus nonlinear and dispersive processes have been studied to a great extent and even the phenomenon of wave breaking has been tackled mathematically though not fully satisfactorialy. The invention of highspeed computers has helped the scientists to attempt problems which are not otherwise amenable.

In this thesis we are analysing some problems of water wave propagation. The problems can be broadly classified into two: (a) The study of waves at the interface of two immiscible liquids, (b) Long wave propagation modelled by Korteweg-de Vries (KdV) type equations.

The thesis consists of four chapters. The first chapter is introductory and gives the basic ideas used in the following chapters.

In chapter two we analyse two problems which falls under the category (a) mentioned above: In the first problem wave propagation at the interface between two inviscid fluids of different densities is studied. The discontinuity in the tangential velocities at the interface gives rise to a vortex sheet whose motion is studied numerically. In the second problem that we discuss in this chapter, wave propagation at the interface between two fluids of different densities where the lower fluid is viscous, is analysed. The integral equation for the interface displacement is solved numerically for different values of Atwood ratio, nondimensional viscosity and Froude number. In both the problems the associated conserved quantities are computed to check the accuracy of computation.

It is well known that the KdV equation represents waves on shallow water which are propagated as solitary waves, since the nonlinear and dispersive effects are balanced. Korteweg and de Vries derived the equation assuming that the depth is constant. In recent studies by a number of scientists, it has been found that KdV type equations arise in many other problems of water wave propagation, in particular when the depth of the channel is not constant. The wave propagation is governed by the equation which can be reduced to a KdV equation with variable coefficients, the coefficients being functions of time. In chapter three we consider a model equation which is a KdV equation, the coefficients being time like variables. The integrability of this equation is studied by Nirmala Antharjanam ('Studies on KdV Equatiuons', Ph.D. thesis, 1987, Cochin University of Science and Technology). Here we consider the numerical solutions of this equation in different cases, viz. the integrability condition is satisfied and not satisfied. It is found that the solution is soliton, only in the case in which the equation can be transformed to the classical KdV equation. The conservations of momentum and energy provide a check for the accuracy of the computation.

In chapter four we consider the long wave propagation when there is a sharp discontinuity at the bottom, forming a shelf. The problem is first attempted by considering the wave as a solitary wave running over a shelf. The method of characteristic can predict only the deformation of wave profile and its breaking. In this chapter a new KdV type equation which accounts for the discontinuity, in terms of generalized functions is derived. The equation is studied analytically.

We conclude the thesis pointing out the salient features of our studies and scope for further work.

# Faculty of Science
## (Physics)

### S.P.1. SANTHAKUMARI, B.–Studies in molecular mechanics using spectroscopic data: exact force field and bound inhomogeneity–1977-Dr. M.G. Krishna Pillai.

This thesis deals with one of the important problems of molecular dynamics--the determination of unique molecular force field from observed vibrational frequency data.

Chapter I is a general introduction in which the various types of assumed molecular force fields in use and different methods of calculation of force constants are reviewed briefly.

Chapter II deals with the problem of determination of force constants using isotopic frequencies. Of the many attempts made, one of the latest and probably the most elegant one seems to be the parameter method. In this attempt a graphical method, making use of isotopic frequencies, is followed. It has been observed that many times it is not possible to have a unique solution, especially if the number of isotopic species exceeds two. In the first part of the chapter criteria for the selection of correct solution, out of the many problems ones, are laid and applied to a few molecules. In the second part of the chapter, within the framework of parameter formalism, a new method and the relevant theory for the determination of exact force field from isotopic frequencies are put forward. The merits of the new method and its superiority above the other existing methods are discussed.

The remaining chapters, except the last one, deal with the study of the spatial distribution of bonding forces between atoms in a molecule. Such a study has not been made till now. To characterize the non-symmetric variation of binding forces at the centre of a bond (b), a bond asymmetry parameter is defined in terms of cartesian force constants. Theoretical expressions for the asymmetry parameters are derived with particular reference to the bent $XY_2$, planar $XY_3$, pyramidal $XY_3$ and tetrahedra, $XY_4$ type molecular models. Results obtained in the case of typical molecules for which established valence force fields exist indicate that the asymmetry parameter is related to molecular properties and the parameter has definite characteristics such as approximate invariance in the case of $XY_3$ ($D_{3h}$) and $XY_4$ ($T_d$) molecules, for each molecular model. On the basis of the relatioship between the bond asymmetry parameter and molecular properties, the force fields of a number of molecules have been evaluated thereby bringing out the significant role this newly formulated parameter can play in the determination of force field.

The last chapter of the thesis deals with the IR spectrum of Coumarin and an explanation for the doublet nature of the carbonyl bond is given.

The original contributions contained in the thesis are the following:-

1. Additional criteria for the selection of exact solution out of the many probable ones obtained in the graphical method in parameter formalism are put forward. The validity of these criteria is tested.
2. A new algebraic method is formulated to employ isotopic frequency data in the determination of molecular force field. The advantages and superiority of this method are brought out.
3. An asymmetry parameter to characterize the non-symmetric variation of binding forces at the centre of a bond is defined.
4. General theoretical expression for the bond asymmetry parameter is derived.
5. The theory thus developed is applied to different molecular species and general conclusions regarding its properties and the usefulness of asymmetry parameter in molecular force field detemination are drawn.
6. IR spectrum of Coumarin is recorded and an explanation for the doublet nature of the carbonyl bond is given.

## S.P.2. SASIDHARAN NAIR, S.–Studies in molecular dynamics. New criteria for the evaluation of intermolecular force fields —1978–Dr. K. Babu Joseph.

It is proposed to submit a thesis for the Ph.D. degree in Physics of the Cochin University. The thesis would deal with some studies in molecular dynamics using spectroscopic data such as vibrational frequencies, mean-square amplitudes of vibrations and coriolis constants. The basic problem in molecular force field evaluation is the determination of n (n+1)/2 force constants using n vibrational frequencies. Eventhough the exact harmonic force fields remains undetermined in the absence of additional data, various approximate force fields may be postulated and physically significant set of force constants elucidated using vibrational frequencies and molecular structural data as input. Iterative as well as noniterative approximation procedures have been reported in the literature during the past few years. Some of the techniques are tailored to suit particular classes of molecules. Iterative methods depend on the choice of the initial set of force constants. In the absence of additional data it is always necessary to resort to approximations. Two new approximation procedures, the "variation method" and the "average bending energy criterion" have been developed by the candidate and successfully applied to more than about 100 molecules belonging to various meodels. The results obtained compare extremely well with the exact force fields determined with the help of additional data.

### The Variation Method

Eventhough the variation technique occupies a prominent position among quantum mechanical methods of computation of eogenvalues, it has not yet been exploited in force constant calculations. Accordingly the variation method has been applied to the evaluation of molecular force fields using the parameter representation. A formulation of the variation method for the evaluation of molecular force fields using the parameter representation. A formulation of the variation method for the evaluation of force constant matrix F is outlined and adapted to deal with second order problem. The method is applied successfully to several hydrids belonging to the bent $XY_2$ model. This method works in cases where the mass ratio $m_Y/m_X$ is very low. The variation method gives excellent force fields in molecules like $H_2O$, $H_2S$ and $H_2Se$.

### Parameter Representation of the Average Potential Energy of Zero Point Vibrations

This comprises a study of the various contributions to the average potential energy terms due to zero point vibrations in various molecular models as a function of the force field parameter. In the bent $XY_2$ model the potential energy of the general valence type in terms of internal coördinates $r_i$ is given by

$$\begin{aligned} 2V = {} & f_r[(\Delta r_1)^2 + (\Delta r_2)2] \\ & + r^2 f_\alpha(\Delta\alpha)^2 + 2 f_{rr}(\Delta r_1 \Delta r_2) \\ & + 2 r f_{r\alpha} \Delta\alpha(\Delta r_1 + \Delta r_2) \end{aligned}$$

Averaging this

$$<2V> = 2 f_r \sigma_r + f_\alpha \sigma_\alpha + 2 f_{rr} \sigma_{rr} + 4 f_{r\alpha} \sigma_{r\alpha}$$

Using the symmetry coordinates and parametrizing $F_{ij}$ and $\Sigma_{ij}$ the variation of the four different contributions in the average potential energy is studied. In order to avoid higher vibrational states and consequent variation of <V> with temperature, the ground state alone is considered. From this study the minimum of the bending energy term $f_\alpha \sigma_\alpha$ gives a criterion for the determination of molecular force fields which are in complete agreement with those fixed using additional experimental data. Other terms do not give any valid minimum. The method is extended to $XY_3$ ($D_{3h}$), $XY_3$ ($C_{3v}$), $XY_4$ ($T_d$) and $XY_6$ ($O_h$) molecular models and in all these cases the average bending energy minimum turns out to be a unique criterion for fixing the molecular force fields provided the orbital following effect occurs in the vibrational species under study.

## S.P.3. MATHEW, K.T.–Beam shaping of sectoral electromagnetic horn antennas using corner reflector technique–1978–Dr. K.G. Nair.

Elecctromagnetic horn radiator is a convenient form of directional antenna in high frequency circuits. An antenna is a device for transmitting or receiving electromagnetic radiation. Horn antennas are used as primary antenna and also as the primary feed of the secondary antennas like paraboloidal reflectors, which are widely used in radar systems. For getting radar beams of desired directional properties, patterns of the ekectromagnetic waves from the horn should be properly shaped. Thus shaping of beam from the elecromagnetic horns has got special significance and practical applications.

Flared section of a waveguide is called an electromagnetic horn. If the flaring is on both the H - plane and E Plane it is a pyramidal horn. A sectoral horn is one which has flaring either in the H - plane or in the E - plane. Thus we have H - Plane sectoral horn and 3 plane sectoral horn. This flaring will provide better impedance matching and reduce sidelobes and backward reflection at the mouth of the guide systems. But it has inherent limitations such as end effect and excitation of higher modes.

Kraus suggested a beam antenna called corner Reflector or 'V' antenna. The feed of the corner relector antenna is dipole placed at the apex of the reflector. The gain and the directional pattern of the corner reflector can be conveniently adjusted by varying the spacing 's' of the dipole or the corner angle 2 or both.

In the present investigation possibility of beam shaping of sectoral horns and corner reflector systems with more parameters, has been studied. Flanges attached at the mouth of sectoral horns are capable of modifying the radiation patterns of the horns. This flange technique in its earlier form has been adopted by many workers with considerable success. More variable parameters are introduced in the flange technique and corner reflector technique. A comparative analysis of the results obtained with a flanged sectoral horn and corner reflector systems shows that both the system give similar results in almost all aspects. The variation of the on axis power with respect to the position of the primary feed, changes in the radiation patterns due to various flange or corner reflector parameters; changes in the beam shape due to various asymmetries imposed on the systems are all found to be identical.

The theoretical study shows that the corner reflector theory is most suitable to explain the beam shaping of flanged 3 and H - plane sectoral horns. The earlier line source theory was suitable only for H-Plane horns. The difficulty in explaining the results with flanged E - plane sectoral horns is thus solved by this uniform theory. However the corner reflector theory is not capable of explaining the asymmetric patterns exhibited by both the systems. For this we have to stick on the previous line source theory.

In short, the flanged sectoral horn antennas and corner reflector systems are one and the same, though there exists structural differences between the two.

## S.P.4. SABIR, M.–Investigations on pathologies in higher spin field theories–1978–Dr. Babu Joseph.

This thesis deals with studies on cetain aspects of pathological higher spin field theories. It brings to light some new abnormalities and new examples of abnormal theories and also puts forward a novel approach towards the construction of trouble-free theories.

Chapter I of this thesis presents a survey of different formulations of higher spin fields and the variety of pathologies afflicting such theories.

Chapter II contains a simple example of a pathological theory involving vector and scalar particles.

In chapter III, as a preliminary to an analysis of the question of relativstic covariance of pathological theories at the classical level, the Dirac-Schwinger covariance condition is derived within a classical framework.

Chapter IV contains a study of the problems of relativistic covariance at the classical level with regard to several interactions of spin 1 field. It is found that while the acausal interactions lead to noncovarioance, there are examples where the field propagation is causal but the theory is nevetheless noncovariant.

Chapter V presents a new approach to higher spin field theory. It is suggested that the method of keeping the subsidiary conditions separate from the equations of motion in a consistant way by means of a Largrange multiplier field may be a solution to the maladies of higher spin field theories. The distinctive features of the approach are illustrated with the example of spin 3/2 field. It is shown that the theory is casual and free of imaginary values in the energy spectrum when coupled to an external electromagnetic field. Quantization is carried out in an indefinite metric space and for minimal coupling a unitary S-matrix is constructed by introducing a fictitious particle and a new vertex.

Chapter VI extends the Lagrange multiplier formalism to the description of a spin 2 field. The massless limit of the corresponding theory is also discussed.

## S.P.5. ANNIE JOSEPH VALLAMATTOM–Studies in molecular spectroscopy–(1) Approximation methods in molecular internal mechanics. (2) Infrared spectral studies of ternary liquid systems and polymer thin film–1979–Dr. M.G. Krishna pillai.

The present thesis consists of two parts. The first part deals with some studies in molecular internal mechanics using spectroscopic data. Two new approximation procedures, "The method of equal co-ordinates" and the hybrid high low frequency separation (HLFs) method are developed and applied to second order and third order vibrational problems. One of the latest methods for the exact determination of molecular force fields is the parameter technique making use of isotopic frequencies. This method is usually successful only in second order problems and even here uncertainties exist in fixing the final force field. A new method termed "method of equal co-ordinates is suggested for the evaluations of force constants in such cases. Another interesting fact that has been studied is the existence of a linear relation between parameter and isotopic mass ratio. This relation is made use of in the evaluation of force constants. The hybrid HLFs method developed in the present thesis is a parameter formulation of Wilsons high low frequency separation combining isotopic spectral data. This method is superior to the traditional HLFs method in the sense that it enables the evaluation of all the twelve force constants. Force constants evaluated by these methods agree well with previously reported values.

In the second part infrared spectral studies are conducted in ternary liquid systems for the evaluation of association constant. Also polymer thin films are prepared and IR spectra of these films are recorded. Different methods described in literature for the evaluation of association constants make use of integrated intensity measurement to determine the concentration of the complex formed which is a tedious task. Hence an easy method is suggested for the evaluation of association constants. The concentration of the complex formed is determined by keeping the concentration of the donor compound at a low constant value and varying the concentration of the acceptor at regular steps. The association constants evaluated by this method agree well with that calculated by the integrated intensity method. The matrix isolation method of forming vapour film is modified in a suitable way to prepare polymer films. An electrodless R.F. discharge is used to obtain the polymer thin film. The IR spectra of the polymer thin film formed by this glow discharge method is taken and the characteristic bands of the polymer are identified.

## S.P.6. JOY, E.C.–A study of the effect of electrode and overlayer films on the electrical properties of certain metal films–1981–Dr. Joy George.

The thesis consists of a study of the effect of electrode films and overlayer films on the electrical properties of certain metal films. The films have been prepared in glass substrates by thermal evaporation in a vacum $10^{-5}$ Torr. The properties of A1 films on ag, Al, An and Cu electrodes, Ag, Al, Au and Cu films on In electrodes. and Bi/Ag bilayer films have been studied. The influence of annealing electrodes at higher temperature on the electrical properties of metal films has also been investigated. Further, the effect of varying layer thickness in the bilayer films, both annealed at higher temperature and annealed at room temperature have been examined.

The percentage variation of resistance with time of the films is found to differ with annealed and unannealed electrodes. In Al films the resistance is found to increase with time. The variation has been more in the case of Au, Ag and Cu electrodes while this has not been very marked in the case of Al electrodes. In Cu films with In elctrodes, the percentage variation of resistance with time was very small and was almost equal in both the films with annealed and unannealed electrodes. Al films with unannealed electrodes showed a non-uniform, rapid increase in the percentage variation which was very large compared to that of the films with annealed electrodes. Unlike the other films, Au and Ag films with In electrodes showed a decrease in resistance with time. In these, the films with unannealed electrodes showed larger percentage variation. The role of various factors such as diffusion and alloying at the film electrode junction, oxide formation and bubble formation have been discussed in the light of the observed variation in resistance of the films. An attempt has also been made to correlate the variation of resistance with the microscopic features seen on particular electrode-film junctions.

In Bi/Ag bilayer films, a thin overlayer of Ag( 50A) has increased the $T_T$/R variation with temperature, where $R_T$ is the resistance of the film at a temperature T and R that at room temperature. It has also increased the resistance of the film, made the TCR at room temperature more negative and shifted the resistance minimum to a higher temperature. The resistance variation with temperature has been explained on the basis of Kaidanov and Regal model.

When the total thickness of the bilayer film was kept constant and individual layer thickness varied, the resistance variation on annealing to a temperature above 160°C has been found to depend on the Ag layer thickness. With increasing Ag layer thickness, the sheet resistance of the films having more than 100 A Ag decreased and the TCR at room temperature changed from negative to positive value. The rapid resistance rise above 100°C observed in films having 100 A to 600 A Ag overlayer has been explained on the basis of diffusion at the interface and aggregation of Ag film on the surface. By controlling the thickness of the layers it is possible to keep the resistance variation with temperature to a minimum. The gradual change of colour of the surface, transparancy of the film, increased adhesive force etc. observed in films annealed at room temperature have been explained on the basis of reduction in crystallite size as evidence by X-ray diffraction and the likely formation of some interphase compound.

## S.P.7. PREMACHANDRAN, S.K.–Growth and characterisation of certain organic crystals–1981–Dr. Joy George.

The thesis presents the results of the investigations on the crystallisation behaviour, defect structure and electrical properties of certain organic crystals Phthalic Anhydride and Potassium Acid Phthalate.

Hollow crystals of Phthalic Anhydride were grown from vapour. The morphology of those hollow crystals were studied in detail and a mechanism for their growth has been proposed. A closed crystal-vapour system was used to study the basal plane growth of the whiskers and the sequential growth observed, confirmed the mechanism suggested for hollow crystals. The dendritic crystals of Phthalic Anhydride were grown, both from the melt and solution. The observed morphologies of these dendrites are described.

Spherulites of Phthalic Anhydride have been grown by the artificial initiation of nucleation, from melt and solution. The variation of the substructure of these spherulitee with the growth temperature was investigated. The spherulitic films having ribbon substructure were etched to reveal dislocations. A mechanism for the formation of the observed etch pattern has been suggested. The slip occuring in these ribbons were studied and the results are presented.

Large single crystals of Phthalic Anhydride were grown by the Bridgman method. The shape of the growth tube, pull rate and temperature profile suitable for growing good single crystals were determined by trial and error. Potassium Acid Phyhalate single crystals were grown from aqueous solutions. The addition of thiourea has been found to promote growth in the <001> direction.

Phthalic Anhydride crystals were cleaved along the (110) planes and cut perpendicular to it. The Potassium Acid Phthalate crystals were cleaved along the (001) plane and cut into slabs having (010) and (100) faces. The cleavage surface of Phthalic Anhydride and Potassium Acid Phthalate crystals were examined by optical techniques and surface topography has been studied.

Of the various etchants used, $NH_4OH : H_2O$ in the ratio 1 : 3 by volume have been found to delinsate dislocations on the (001) and (110) surfacer of Phthalic Anhydride. The morphology of etch pits on these faces have been studied in detail and the dislocation densities on them have been determined. On Potassium Acid Phthalate cleavage surface, an etchant consisting of one part of water in five parts of acetone by volume was found suitable to reveal the dislocations. The dislocation configurations on these crystals have been examined by successive etching. The effect of annealing on these crystals has been discussed in the light of the observed dislocation configurations. Pyramidal indentations were made on the different faces of these crystals and the slip traces observed were used to identify the slip planes.

The anisotropy of electrical conduction in Phthalic Anhydride and Potassium Acid Phthalate single crystals were investigated by measuring the conductivity in the various directions at different temperatures and the activation energies have been calculated.

## S.P.8. RADHAKRISHNAN, M.K.–An investigation on the electrical characteristics of antimony trisulphide films and certain metalsemiconductor ($Sb_2S_3$) contacts–1981–
Dr. Joy George.

The thesis consists of the study of the electrical properties of antimony trisulphide films and the electrical behaviour of different metal contacts to these antimony trisulphide films. Antimony trisulphide films for the study were mostly prepared by the three temperature method, at a partial pressure less than 1 ×

303 K to 473 K, it is found that below 450 K ionic conduction is predominant in silver sulphide films. Ferric hydroxide films pictured an intrinsic conduction above 313 K and below 313 K an impurity conduction.

Polymer thin films of para-toluidine have been prepared in a radio frequency glow discharge from the monomer para-toluidine in a vacuum of the order of $10^{-2}$ torr. A radio frequency oscillator of frequency approximately 4.5 MHz, fabricated, has been used as the power source for polymerization. A vacuum set up together with the plasma zone to suit the necessities of polymerization has been designed and fabricated using corning glass.

Infra red studies of the film proposed that the polymerization is by hydrogen abstraction and polymer units are linked with polar c-N bonds. Also the film suggest the presence of cross-links in them.

The current-voltage characteristics of the electrodeless glow discharge polymerized films sandwiched between aluminium electrodes showed ohmic conduction at low fields and square law region at high fields.

The dielectric studies of the films revealed temperature dependence of dielectric constant and dielectirc loss and the variation of capacitance with film thickness at a fixed frequency of I KHz. The preperties of these film were found to be comparable with high quality films.

## S.p.13. SYAMA PRASAD, U–Electrical Properties and Phase Transitions in some Ammonium containing Ferroelectrics –1982–Dr. C.P. Girijavallabhan.

The thesis presents the results of the experimental investigations on electrical properties like electrical conductivity, eielectric constant and ionic thermo-current in certain ferroelectric single cystals (Viz; $LiNH_4So_4$, $(NH_4)_2SO_4$, and $(NH_4)_3H(SO_4)_2$) containing ammonium groups. Special emphasis has been given in revealing the mchanisms of electrical conduction in the various phases and at the transition points of these crystals by studying doped, quenched and deuterated samples. Reports on observation of two new phase transitions in $(NH_4)_2SO_4$ and one in $(NH_4)_3H(SO_4)_2$ are also included. The relaxation mechanisms of the I-V complexes and the space charge phenomena in pure and doped crystals of $LiNH_4SO_4$ and $(NH_4)_2SO_4$ and the observation of a new type of ITC viz; protonic Thermo-Current (PTC) in these crystals are also presented.

The thesis contains seven chapters of which Chapter I is of introductory nature. Some general considerations on the scope and importance of the present investigation, theoretical background, various experimental techniques pertinent to phase transitions in solids, ferroelectricity, ionic conductivity and TSD processes and the current status and application are presented in this chapter. Chapter II deals with the experimental techniques and method of measurements used in this investigation.

The electrical conduction mechanisms in the above crystals are discussed in chapters III, IV and V on the basis of the electrical conductivity results on pure, doped, quenched and deuterated crystals. A-type conductivity anomalies are observed in all these crystals corresponding to their phase transition points. The transitions are interpreted on the basis of the concepts of free rotation of the ammonium tetrahedra (high-temprature transtions) and successive distortions of the non-equivalent ammonium ions (low-temperature transitions).

The dielectric properties of pure and deuterated $LiNH_4SO_4$ and $(NH_4)_2SO_4$ are presented in chapter VI. These properties are coroborated with the electrical conductivity results. The phase transtions observedd by electrical conductivity studies are confirmed by dielectric measurements. An extensive study of ITC in pure and doped $LiNH_4SO_4$ and $(NH_4)_2SO_4$ is presented in chapter VII. A detailed investigation the ITC spectra of these crystals as a function of impurity concentration, poling temperature, poling time and polarising field has been conducted and presented.

## S.p.14. VASUDEVAN, K. Investigations on the Radiation Characteristics of Flanged Sectoral Horn Antennas and Corner Reflector Systems–1982–Dr. K.G. Nair.

Improving the performance of sectoral horns and corner reflector antennas have been a subject of interest for many years, because of their suitability in communication and radar applications. The use of corrugated surfaces have already been proved to be effective in improving the radiation characteristics of sectoral horn antennas. In the present study, the possibility of controlling the different antenna characteristics like radiation patterns and matching conditions of sectoral horns and CR systems have been investigated in detail.

Investigations werre carried out on the various antenna characteristics of plane flanged sectoral horns and plane CR systems. The important aspects taken for this study include the variations in beamshape, gain and impedance conditions with various parameters like frequenmcy and included angle of flangers or reflectors. A comparative analysis between the results obtained with both systems have indicated an analogy between the behaviour of flanged horns and CR systems. The new type of corner reflector system with corrugated reflector elements have been investigared in detail and the experimental results regarding half power beamwidth (HPBW) are also presented. This system gives better performance than conventional corner reflector with plane lements. Intense study of flanged sectoral horns and corner reflector systems using corrugatedd flanges and corrugated reflectors were performed to investigate the validity of the analogy between the two systems and to improve the performance of these antennas. A method has also been developed to obtain elliptically and circularly polarized radiation from both flanged horns and CR systems using surfaces with inclined corrugations.

A theoretical analysis of the radiation from flanged sectoral horns is attempted on the basis of the Line source Theory. For explaining the results obtained using CR system, the method of images have been employed. Radiation patterns were computed on the basis of these theories and they show fairly good agreement with the experimental results.

While taking antinna measurements inside an anechoic chamber, an antinna (turn-table) has been used. The positioner is fully automatic and is operated from outside where recording instruments are arranged. This remote control system was designed and fabricated as an ancilliary work and a description of this is presentedd in this thesis as an Appendix.

A major part of the work presented in this thesis was performed inside a microwave anechoic chamber, the design and fabrication of which was completed during the time of this research work. The performance evaluation of this chamber

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was a part of the activity of the author. This evaluation procedure and the results therefrom are discussd and presented as another Appendix.

## S.p.15. BALAKRISHNA WARRIER, K.–Thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy–1982–Dr. C. Purushothaman

The thesis deals with studies on several prperties of anisotropic super-conductors containing paramagnetic impurities in Shiba-Rusinov model.

I have investigated the effect of gap anisotropy on the Josephson current for an impure superconductor described by SR model. It is observed that as the impurity concentration is increased, the Josephson current gradually decreased and finally goes to zero for a particular value of the impurity concentration. For a given impurity concentration if we increase the Josephson current also increased. The values of the normalized Josephson current for various values of impurity concentration and for two values of the local states within the gap & are given in Table 1. Figure 1 shows the nature of variation of the normalized Josephson current with $T/T_c$ for = 0.95. We noticed that when C = 0.2, the effect of anisotropy is to decrease Josephson current. As we increase the impurity concentation the Josephson current will be increased due to anisotropy.

When $T_K/T_{co} > 1$ as we increase $(T/T_{co})$ we found that the percentage change in the slope of Josephson current versus $(T/T_{co}$, K* gradually decreases where as when $(T_K/T_{co})$ is less than one, the above quantity increases as we increase $(T/T_{co})$.

The slope of Josephson current versus $(T_c/T_{co})$, K* is tabulated for various values of $T_K/T_{co}$. For $(T_K/T_{co})$ 1, as more and more impurities are added, the effect of anisotropy is to increase the percentage change in K* due to anisotropy. For $(T_K/T_{co}$ 1, increase of impurity will decrease the percentage change in K* due to anisotropy.

When $<a^2> = 0.01$, K* = 0.16 giving a 24.03% deviation from previous calculations. $K^*_{AG} = 0.129$ (for = 1 and $<a^2> = 0$). As the strength of interaction increases ( <1) the effect of anisotrophy on $\Delta(C,T)$, $H_C(C,T,\ )$ and $J_s(C,T,\ )$ is small, but if the strength of interaction decreases (  -1) the effect of anisotrophy is more prominent. For a given value of  , for small impurity concentration, the effect of anisotrophy is to increase $\Delta(C,T)$, $H\times(C,T,\ )$ and $J_s(C,T,\ )$ but for large impurity concentrations the effecct of anisotropy is to reduce teh above quantities.

I have calculated the anisotropic density of electronic states, (N(w)/N(O). Outside BCS energy gap $(w/\Delta>1)$ density of states will be decreased due to anisotropy and inside BCS energy gap $(w/\Delta<1)$ it is increased for anisotropic superconductors.

For given impurity concentration as we increase the strength of interaction (decrease ) we observe that the percentage change in the normalized zlope of ultransonic attenuation coefficient $(C^*/C^*_{AG})$ will be more.

The normalized upper critical field $h_{c2}(T)$ increases due to anisotropy as we increase the impurity concentration. For a given impurity concentration as we increase the strength of interaction, anisotropy will increase the percentage change in $h_{c2}(T)$.

The normalized slope of upper critical field versus $T/T_c$, $h_{c2}(T)$ also behaves the same way as $h_{c2}(T)$ with anisotropy.

I have observed that the local stats within the BCS energy gap is anisotropic.

The response to a weak transverse electromagnitic gield is studied for an isotropic superconductor. The response function agrees with equation (16) of K. Maki (54). In the limit of $q_0 \rightarrow 0$, the equation (3.117) reduced to that of Chaba (55).

The Kondo effect of some of our problems is also investigated.

## S.P.16. SEBASTIAN, P.J.–Fabrication and parametric measurements of N2 laser pumped dye laser and its application to energy transfer studies in mixed dyes–1982– Dr. K. Sathianandan

This thesis reports a detailed study of the performance characterisation of a $N_2$ laser-pumped-dye laser in the conventional mode and also when pumpd by the energy transfer mechanism. It was shows that performance characteristics of the due laser can be controlled by system parameters. Suitable modifications were suggested for obtaining better conversion efficiency and bandwidth.

## S.p.17. PAUL, C.M.–Studies on molecular structure and properties using microwave and infrared spectral data –1983–Dr. C.P. Girijavallabhan.

This thesis reports certain computational precedures to extract maximum amount of information regarding the geomerical structure and inter-atomic forces of simple molecules from experimental data on microwave and infrared spectra. A novel feature of these studies is the use of centrifugal distortion constants for the detrmination of the geometry of symmetric top molecules. The method developed here shows that reliable information of the molecular geometry can be carried out even when the microwave spectrosoopic data on isotopic molecules are not available.

## S.p.18. MOHANACHANDRAN, K.–Formation and electrical properties of polyacrylonitrile thin films prepared by plasma–polymerisation–1983–Dr. K. Sathanandan

Plasma-polymerised PAN thin films sandwiched by aluminium electrodes were prepared. The mechanism of plasma-polymerisation was studied by analysing the emission spectra formed from acrylonitrile vapour. Thermally stimulated current in PAN was studied to obtain information regarding the dipolar orientation and charge storage mechanism in the polymer. Dielectric and electrical properties of PAN film were also studied.

## S.p.19. KURIAKOSE, V.C. Studies in quantum field theory at finite temperature–1983–Dr. K. Babu Joseph

The thesis deals with certain quantum field systems exhibiting spontaneous symmetry breaking (SSB) and their response to temperature. These models are of interest in particle sphysics, solid state physics and nonlinear optics. The nature of phase transition that these systems may undergo is also investigated. The main theoretical tools employed to understand these properties are the lattice formalism, effective potential method and the renormalisation group.

Lattice gauge theory is a nonperturbative formalism and constitutes an attempt to explain various problems in quantum field theory, which were hitherto unanswered. Phase transition is a process associated with the change of symmetry. Sine-Gordon field system is a nonlinear scalar field theory exhibiting SSB. The present investigation reveals that the Sine-Gordon field system in 1+1 dimension undergoes a second order phase transition from the disordered phase characterised by< > = 0 to the ordered phase characterised by <Ø>= 0 where < >denotes the vacuum expectation value. The critical values of the parameters which characterise these two phases are also evaluated. The method is extended to generalised sine-Gordon field systems exhibiting a second order phase transition.

The fact that SSB in relativistic field theories disappears when the temperature of the system is increased above a critical value has significant consequences in particle physics. The relationship between SSB anmd temperature is investigated via the effective potential defined at finite temperature. As an application of this formalism, the effect of temperature on the 1 + 1 dimensional sine-Gordon field system is studied. The effective potential at the one-loop order at zero temperature is evaluated first. By evaluating the effective potential at finite temperature, the critical temperature above which the system regains the original symmetry is obtained. The soliton energy at finite temperature is found to be less than the classical soliton energy, and decreases smoothly with temperature and finally vanishes at the critical temperature, signalling a second order phase transition. The calculations are extended to the generalised sine-Gordon models.

The formalism discussed above is extended to field systems in 1 + 1 dimensions, which is a nonlinear field theory exhibiting SSB. This model is of importance in the theory of ferroelectric and structural phase transitions encountered in solid state physics. The effective potential at finite temperature is evaluated. The calculations are done upto two-loop level. The critical temperature above which the system regains the symmetry property is calculated.

With the advent of the Grand Unified theories studies on finite temperature behaviour of quantum field systems are of prime importance since these studies will help us to speculate on the evolution of the universe at times as early as $10^{-35}$ sec after the big bang. In these studies the dependence of the coupling constant on temperature is to be taken into account as it can reduce drastically the amount of supercooling associated with the first order phase transition in grand unified theories. Using the vertex renomalisatin procedure, the temperature behaviour of the coupling constant in two models is investigated. The massive Ø theory is considered first. The present investigation shows that when $m^2>0$, the coupling constant decreases with temperature leading to a phase transition to a non-interacting phase. In a model with $m^2< 0$, the coupling constant increases logarithmically. A renormalisation group study of the problem also supports these results. The temperature behaviour of the gauge coupling constant in scalar electrodynamics is also studied and it is found that the gauge coupling constant uniformaly increases with temperature. This investigation is of relevance to Grand Unified Models of Cosmological evolution.

### S.p.20. JOSEPH, K.S.–An investigation on the preparation and properties of certain semiconducting sulphide thin films–1984–Dr. Joy George.

In this thesis the preparation and properties of thin films of certain semiconducting sulphides are reported. The films were grown by reactive evaporation and also by a new technique of activated reactive evaporation. The films were characterised with respect to their structure and morphology by X-ray diffraction, scanning electron microscopy and optical microscopy.

### S.p.21. MURALEEDHARAN PILLAI, S.–Studies on electroluminiscence using powder and thin film devices–1984–Dr. C.P. Girijavallabhan.

The studies discussed in this thesis were related to the development of some new phosphor materials and their uses in powder and thin film electroluminiscent devices and to their electrical and spectral characteristics. A number of EL phosphors were prepared and their properties studied. Emission spectra, I-V characteristics and B-f characteristics and brightness waves were analysed and a number of new results obtained.

### S.p.22. SUDHA KARTHA, C–Nitrogen Laser Excited Fluorescence of some Rare Eart Doped Alkaline Earth Fluorides–1984–Dr. K. Sathianandan.

The spectroscopic studies of doped crystalline substances have revealed the possibility of their use in lasers. In the recent years to come, we may expect a large scale intensive search for laser crystals capable of efficient emission at room temperatures both in the ultraviolet and in the visible regions of the optical spectrum. The possibility of using rare earth ions in crystals as new laser materials has necessitated a complete understanding of the excitation and de-excitation mechanisms of these ions. The advent of lasers initiated the most interesting and highly detailed investigations into the spectroscopic features of laser crystals like $CaF_2:RE^{3+}$.

This thesis aims to present the results of the experimental investigations on the Nitrogen laser excited fluorescence of some rare earth doped alkaline earth fluorides. It also contains the details of a pulsed Nitrogen laser, a fluorescence emission spectrometerand a lifetime spectrometer.

The thesis begins with a brief introduction to the different aspects of the luminescence in crystals. The different factors affecting the luminescence and the application of luminescence are described in this chapter. A brief introduction to laser crystals and the spectral characteristics of rare earth ions are also discussed in the second half of the chapter.

It has been observed that a good number of rare earth ions in different crystals absorb the UV radiations of the Nitrogen laser to emit fluorescence in the visible region. Moreover, being a pulsed laser with very high peak power of extremely short duration, lifetime measurement of excited states can be successfully carried out using this laser. A Nitrogen laser was therefore used as the source of excitation in the present investigations and the details of its design considerations are given in the second chapter. Some parametric studies like the power measurements, laser spectrum analysis and power variations with additives are also carried out on this laser and the results are presented in the same chapter.

The experimental details on the recording of the fluorescence spectrum and lifetime measurements are given in the successive chapters. Since a knowledge of the behaviour of the pure materials can provide a basis for understanding the behaviour of the doped materials, the fluorescence spactra of pure $CaF_2$, $SrF_2$ and $BaF_2$ were initially investigated with the Nitrogen laser excitation and the results are presented in chapter III.

Fluorescence studies of $CaF_2$:$Ho^{3+}$ for different concentrations of $Ho^{3+}$ are described in the next chapter. The emission spectra are recorded at both RT and LNT. Temperature dependent concentration quenching of fluorescence was observed for $CaF_2$:$Ho^{3+}$ and is discussed with the help of the energy level diagram of $Ho^{3+}$.

Visible fluorescence of $Nd^{3+}$ in $CaF_2$, $SrF_2$ and $BaF_2$ for two different concentrations of $Nd^{3+}$ is also studied with Nitrogen laser excitation and presented in chapter V. Strong blue emission was observed from these crystals. The energy levels and transitions involved in the visible fluorescence of $Nd^{3+}$ are also included in this chapter.

The study of fluorescence of $CaF_2$:$Er^{3+}$ is given in chapter VI. No visible fluorescence was observed under Nitrogen laser excitation and hence the emission of these crystals was studied with a Xenon are excitation. The results and conclusions of the investigations are summarised in a separate chapter at the end of the thesis.

The results of the above investigations have been communicated in the form of following research papers.

1. A simple and sensitive PMT preamplifier for low level fluorescence and luminescence studies. S.M. Pillai, C. Raghavan, C. Sudha Kartha and C.P.G. Vallabhan, J. Inst. Soc. India, 2. 7 (1982).
2. Fluorescence of $CaF_2$:$Ho^{3+}$ under $N_2$ laser excitation. Sudha Vijayakumar, V.P.Nampoori and K. Sathianandan, Proceedings of DAE Symp. on NP & SSP held at Banaras Hindu University (1982) Paper SEC11.
3. Blue emission of $Nd^{3+}$ in $CaF_2$ and $SrF_2$. Sudha Vijayakumar, V.P. Namboori and K. Sathianandan, Proceedings of DAE Symp. on NP & SSP held at Banaras Hindu University (1982) Paper SEC11.
4. New vibrational bands in the $N_2$ laser emission spectra. N. Subhash, Sudha C. Kartha and K. Sathianandan, Appl. Optics, 22, 3612 (1983).
5. Temperature dependent concentration quenching of fluorescence of $CaF_2$:$Ho^{3+}$. C. Sudha Kartha, T. Ramachandran, V.P.N. Nampoori and K. Sathianandan, Presented at the 3rd Symp. on Lasers and Applications held at IIT Kanpur (1983) Paper C 2Y-3.
6. Luminescence decay studies of $Nd^{3+}$ in $SrF_2$. C. Sudha Kartha, V.P.N. Nampoori and K. Sathianandan, Proceedings of DAE Symp. on Np & SSP held at Manasagangothri, University of Mysore (1983), SDD5.

## S.p.23. Vijayakumar, K.P.–Surface Studies of some metallic thin films by optical methods–1984–Dr. C. Purushothaman

Optical properties of thin films are wellknown due to the practical applications of thin films in different fields. The main limitation in experimental as well as theoretical aspects of the same was the difficult calculations involved and this has been removed by the introduction of high speed computers. But the factors affecting the surface and structure of films, causing variations in their optical properties, are enormous in number. In this work, the effects of some among them are studied in detail.

The thesis aims to present the results of experimental investigations on the changes of optical properties of metallic thin films due to heating. The parameters which are measured are reflectivity, refractive indices and the ellipsometric quantities and Δ. The materials used in the studeis are metals like Silver, Aluminium andd Copper. By applying the optical method the interdiffusion taking place in multilayer films of Aluminium and Silver has also been studied. Special interest has been taken to reveal the mechanisms of the hillock growth and surface roughness caused by heating and their relation with the stress in the film.

The thesis contains nine chapters which are generally self-contained with separate abstracts; however I is of an introductory nature. It contains some general considerations regarding the scope and importance of the present work. It also gives a brief description of the ddifferent features affecting the optical properties of films and a summary of different methods for its analysis. A brief suvey of the earlier works is also included in this chapter. The present status and some aspects of the application of the optical studies are presented in the second half of this chapter.

The next chapter gives the details of the experimental procedure. It contains the description of method of preparation of the samples and the thickness measuring technique. The experimental set up for annealing and optical measurements are also included in the chapter.

The changes in the reflectivity of Silver films due to annealing in the temperature range 30° C to 300° C are discussed in chapter III. Here the results of annealing in air and vacuum are considered separately. The explanation of these changes is given on the basis of the relationship between the internal stress and the surface energy of the film.

In the chapter IV, the study of interdiffusion in multilayer films by using reflectivity measurements is presented. Here the materials are Aluminium and Silver with the former always forming the lower layer. The changes of reflectivity of both surfaces of the film are studied as a function of temperature. The effect of different thickness ratios of the two layers is also considered.

The chapter V contains the results of the studies on Copper films. Here the temperature variation is from 50° C to 200° C and the thickness of the samples varies from 500° A to 3000° A. From these results an attempt is made to calculate the intrinsic stress values of Copper films of different thickness.

A brief description of ellipsometry, including the basic theory, is presented in the next chapter. It also contains the details of the ellipsometric set up used for the investigation. In the second half of this chapter, the different uses of ellipsometry are included.

In chapter VII. the results of ellipsometric measurements of thermally induced surface roughness (hillock growth) of silver films are presented along with the required theory for the measurement of surface roughness by using ellipsometry. The variation of the hillock growth with thickness of the film is also brought under discussion. This chapter also contains the calculated values of intrinsic stress in Silver films of different thicknesses.

The light scattering measurements can give a lot of information regarding the roughness of film surfaces. Hence the surfaces of the samples analysed by using the ellipsometric method have been again examined by using light scattering technique and this is presented in the next chapter. These confirm the results of ellipsometric measurements mentioned in earlier chapter.

All these observations are summarised in chapter IX. This also points out the importance of the low temperature annealing.

A theoretical study of the lattice dynamics of ZnS crystal is also included as an appendix in the thesis. In this, the phonon frequencies for [100], [110] and [111] wave vector directions are calculated for both normal crystal and isotope substituted one ($Zn^{34}S$). From these two values the eigenvector magnitude is computed for the three wavevector directions.

Part of the investigations presented in the thesis has been published/communicated in the form of following papers:

1. Effect of annealing on the reflectivity of Silver film
   K.P. Vijayakumar and C. Purushothaman
   Thin solid Films 82, 225 (1981).
2. Temperature variations of reflectivity of A1-Ag double layer films
   K.P. Vijayakumar and C. Purushothaman
   Proceedings of Nuclear Physics and Solid State Physics Symposium held at Banaras Hindu University, Varanasi, Vol. 25C, p. 8JB5 (1982).
3. An optical study of the thermal effects on Cu films K.P. Vijayakumar and C. Purushothaman
   Thin Solid Films, 112, 71 (1984).
4. Optical study of surface diffusion in Silver films K.P. Vijayakumar and C. Purushothaman
   Proceedings of Nuclear Physics and Solid State Physics Symposium held at University of Mysore, Mysore, Vol. 26c, p.SAB8 (1983).
5. Lattice vibrations and eigenvector magnitudes in ZnS
   K.P. Vijayakumar and C. Purushothaman
   Indian Journal of Pure and Applied Physics, 19, 749 (1981).
6. Ellipsometric study of thermal effects on Silver films K.P. Vijayakumar and C. Purushothaman
   (Communicated to Surface Science).
7. Hillock growth measurement by light scattering technique
   (Communicated to Applied Optics).

## S.P.24. VALSALAKUMARI, C.K.–Growth and Characterisation of Tin Dichalcogenide Crystals–1985–Dr. Joy George

During the past few decades, a wide spread interest in the structural, optical, electrical and other physical properties of the transition metal dichalcogenide layer compounds has evolved. The members of this family of compounds can be regarded as strongly bonded two dimensional chalcogen-metal-chalcogen layers which are loosely coupled to one another by the weak van der Waal's

forces. Because of this type of bonding, the crystals are easily cleavable along the basal plane and show highly anisotropic properties.

This thesis contains the growth and the study of the physical properties of certain tin dichalcogenide crystals ($SnS_2$and $SnSe_2$). Tin disulphide and tin diselenide crystallise in the hexagonal $CdI_2$ type crystal structure. This structure consists of layers of tin atoms sandwiched between two layers of chalcogen atoms. A tin atom is surrounded by six chalcogen atoms octahedrally. In the layers the atoms are held together by covalent bonding and in between the layers there is van der Waal's bonding.

These crystals are normally grown by chemical transport method with iodine as the transporting agent, the growth time being about 8 to 24 hours. But crystals grown using transporting agent are usually contaminated by the transporting agent and this has a pronounced effect on the physical properties. Therefore physical vapour transport method was used for the growth of crystals in the present investigations. Eventhough a relatively larger period of growth time is necessary for the physical vapour transport method (40-150 hrs), the crystals obtained from this method have a much less impurity concentration than that obtained from chemical vapour transport method.

Since the growth temperatures of tin disulphide and tin diselenide are comparatively high, fused quartz tubes were used for the growth. Stoichiometric proportion of the starting materials were filled in precleaned quartz ampoules and evacuated to a pressure of $10^{-5}$ Torr and sealed. For the growth process a horizontal two zone linear gradient furnace and temperature controllers with accuracy better than ±1°c were used. A source temperature of 700°c and a growth temperature of 630°c was used for the growth of tin disulphide crystals. After a growth period of 40–150 hours, golden yellow platelet like crystals of approximately 1.5 $cm^2$ in area and 10–60 $\mu$ thickness were obtained. For the growth of tin diselenide crystals, a source temperature of 640°c and a growth temperature of 475°c was used. Usually thin platelets of metallic coloured crystals having a thickness of $\leqslant 100\ \mu$ were obtained.

Crystals with good plane surfaces were selected for morphological studies. Beautiful circular and hexagonal spirals were observed on the as grown faces of tin disulphide and tin diselenide crystals. These observations reveal that these crystals grow from the vapour phase by the screw dislocation mechanism. Spirals with hollow core and change of curvature were observed on tin disulphide crystals. The change of curvature of the spiral step depends on the stress field around the dislocation. Eccentric spirals originating from single screw dislocation were also observed. The eccentricity of the spirals depends on the supersaturation gradient of the growth crystal. Eccentric spirals and spirals showing change of curvature were observed on tin diselenide crystals also. One of the most striking features observed on $SnSe_2$ crystals was the interlaced spirals. Interlaced spirals result from the dependence of growth rates on crystallographic direction.

Optical studies provide a wealth of information on the band structure of the semiconductor and also about the impurity levels in the band gap. Optical properties of the crystals were studied by transmission measurements. Refractive index of the crystals was determined from the interference fringes obtained in the transmission spectra of thin crystals. Absorption coefficient was also calculated from the transmission spectra of the crystals.

In tin disulphide crystals, it was found that there is a shoulder in the absorption just before the onset of band to band transitions. This shoulder is caused by transitions from valence band to donor levels (due to doubly ionizable sulphur vacancy) situated 0.17 eV below the conduction band. From absorption edge measurements it was also found that, in tin disulphide the valence band is split into three due to spin-orbit interaction and crystal field splitting.

The fundamental absorption data was analyzed in terms of the theory of Bardeen et.al and from this analysis, an indirect forbidden band gap of 2.07 eV and a direct forbidden band gap of 2.40 eV have been detected in tin disulphide crystals. In the case of tin diselenide crystals, the indirect band gap obtained is 1.03 eV. From the functional dependence of absorption coefficient on photon energy it was found that the transition is forbidden.

Conductivity type of the crystals was determined by the hot probe method. All the tin disulphide and tin diselenide crystals grown were n-type.

From the electrical measurements, activation energy required for conduction, mobility, carrier concentration etc. were determined. Resistivity of tin diselenide crystals was measured at different temperatures and from the temperature dependence of resistivity, activation energy for conduction parallel to c-axis was, obtained (0.072 eV). Resistivity and Hall effect perpendicular to c-axis were measured by van der Pauw's technique. From these values, mobility and carrier concentration of tin diselenide crystals were calculated. From the results it was found that crystals grown by physical vapour transport (carrier concentration $\sim 10^{15}$) are less contaminated than that grown from chemical transport (carrier concentration $\sim 10^{18}$) method.

Electrical conduction mechanism in tin disulphide crystals was studied using A1-$SnS_2$–A1 (MIM) structures. The current voltage characteristics obtained show four discrete regions. At low voltages, the current is proportional to the voltage (ohmic law region) followed by a square law region at high fields. This region is the shallow trap square law region. The square law region is followed by another region where current increases sharply with voltage ($I \propto V^n$; $n \geq 3$) and this is due to the filling up of the traps. This region is followed by the trap free square law region. These observations indicate a charge injection into the semiconductor. The log I versus log d plot in the shallow trap square law region shows a $d^3$ dependence establishing that the conduction mechanism is space charge limited. From the threshold voltage, where the ohmic current cross over to space charge limited current in the absence of traps, the density of thermally generated free carriers was determined (2.3 x $10^{11}$ $cm^{-3}$). Mobility of the charge carriers was calculated using the equation for SCL conduction (6 $cm^2$/V.Sec). From this mobility, conductivity of the specimen was calculated (2.2 x $10^{-7}$ $\Omega^{-1}$ $cm^1$) and the calculated value agrees very well with the experimental value obtained from the ohmic law region. Due to the filling of the traps in the semiconductor, current increases sharply after the shallow trap square law region. The trap filled limit voltage measures the fraction of the total concentration of traps that is empty in thermal equilibrium and from the trap filled limit voltage, the trap concentration was calculated (2.3 x $10^{13}$ $cm^{-3}$). Trap depth, Fermi level, effective density of states in the conduction band etc. have also been determined from the measurements. Dependence of the current on temperature in the ohmic law region gave an activation energy of 0.40 eV.

## S.p.25. MOHANAN, P.–Formation of elliptically polarized beam from H-Plane sectoral horns using corrugated flanges –1985–Dr. K.G. Nair.

Design and development of an elliptically polarized and matched H-plane sectoral horn antenna is reported. By proper trimming of the flange parameters any desired polarization can be synthesized.

First chapter highlights the pioneer works of Maxwell, Hertz, Bose etc. A brief description of different types of electromagnetic antennas, beam shaping in horn antennas, etc. are given with special reference to circularly polarized radiators.

An elaborate review of the past work done in the field of electromagnetic horn antennas, circularly polarized horns, beam shaping of sectoral horns, corrugated horns and surfaces etc. ae given in the second chapter. The review starts from the memorial lecture of Sir Oliver Lodge in 1894.

Third chapter is devoted to the description of the equipment and measurement techniques. Technical details of Antenna Positioner, Antenna Polarization Positioner, Flange Moving Mechanism, etc. are described.

The outcome of the experimental results carried out on H-Plane sectoral horns fitted with tilted corrugated flanges are presented in the fourth chapter. The experimental investigations have been conducted at X-band for the dominant $TE_{10}$ mode. The following antenna characteristics were studied in detail:

1) Co-polar and cross-polar on-axis power density.
2) Polarization pattern
3) Axial ratio
4) Tilt angle
5) Sense of rotation
6) Radiation pattern
7) VSWR
8) HPBW
9) Directive gain

Variation of all these antenna characteristics with various flange parmeters like the position of the flange from the aperture of the horn, tilt of corrugation with H-vector, flange angle, corrugation period and frequency etc. are studied in detail. Following are the important conclusions about the flanged H-plane sectoral horn.

1. It is found that on-axis co-polar and cross-polar power densities are very much dependent on the position of the flange from the aperture. For a particular position of the flange from the aperture, there is an appreciable amount of cross polar component which is nearly equal in amplitude to that of co-polar power when the corrugation tilt angle is 45°. If the tilt angle is greater than or less than 45°, the cross-polar component is very small. So the optimum tilt angle for elliptical polarization is 45°.

Axial ratio is strongly influenced by the position of the flange from the aperture of the horn. Axial ratio fluctuate from a maximum to minimum as the flanges are moved back from the horn aperture. At the certain position the axial ratio approaches 0.26 dB, and the radiation is almost circularly polarized. It is found that depending upon the position of the flange a linearly polarized co-polar or cross-polar radiation can be produced. The observations shows that very low axial ratio can be obtained only when the tilt of corrugation is 45°. For a particular flange, there is an optimum flange angle for which the polarization is nearly circular. The bend width of the present system is found to be 1 GHz is 9 to 10 GHz at X-band. The variation of axial ratio with azimuth shows that the antenna radiation is circularly polarized over an earth coverage angle of 10° in the H-plane. The polarization is essliptical in nature beyond that. Typical curves are given for the variation of axial ratio and tilt of the polarization of axial ratio and tilt of the polarization ellipse with the corrugation period.

Tilt angle of the polarization ellipse is also depending on the position of the flange, flange angle, tilt of corrugation, corrugation period etc. But at the circula polarization position the tilt angle is found to be nearly zero.

The sense of rotation of the polarized wave emanating from a flanged horn is experimentally determined by the use of two identical helical antennas of oppsotite sense. The flanged horn act as an elliptically polarized rdiator in the right handed sense when the tilt of corrugation is 45°. But when the tilt of corrugation is 135°, it is polarized in the opposite sense. Radiation patterns received by LHCP and RHCP helical antennas for different corrugation tilt is shown in fig. (1).

When the flange is at the aperture of the horn VSWR is found to be less than the natural horn. Then it is increased to a high value and then decreased. But at the circular polarization position the VSWR is found to be less than the natural horn (ie., horn without flanges). Therefore matching is found to be improved at the circular polarization position. This observation is again confirmed by the HPBW and Gain measurements.

Drastic changes occur to the polarization of the radiated energy when the position of the flange is moved back from the horn aperture. Radiation pattern are taken in four different planes namely co-polar, cross-polar, 45° polar and 135° polar. For a critical flange position all these radiation patterns are nearly identical, ie., circularly polarized. For certain position the cross-polar component is very small, ie., it is linearly polarized the co-polar plane. For another position the co-polar component is small. But the cross-polar component is increased. In this case it is cross-polarized. Thus any desired polarization can be produced by trimming the position of the flange.

The E-plane radiation pattern of a H-plane sectoral horn or H-plane radiation pattern of an E-plane sectoral can be shaped by the flange technique. When the tilt of corrugation is zero ie., tips of the corrugations are orthogonal to the E-vector, a narrow pencil beam or split beam can be produced using this technique. At the optimum position of the flange all the antenna characteristics like Gain, VSWR, HPBW, band width etc. are improved very much than a natural horn.

At the circular polarization position the beam width of the co-polar, cross-polar, 45° polar radiation patterns are found to be nearly equal. The HPBW is found to be less than that of the natural horn.

The gain of the antenna is also found to be increased at the circular polarization position. A gain of 18 db is obtained at the circular polarization position with a horn of gain 14 dB. When the tilt of corrugation is zero, a gain of 27 dB is obtained with a horn of 8 dB gain in the E-plane.

Theoretical analysis of axial ratio and tilt angle of the polarization ellipse is presented in the fifth chapter. This is on the basis of secondary radiation and the method of images. The incident radiation from the horn is resolved into two

components namely TM and TE waves. The component which is parallel to the tips of corrugation is TE waves and the other perpendicular to that is called TM waves. TE waves are completely reflected from the tips of corrugation but TV waves propagate into the slot and reflected back. The amplitude and phase of these two waves are calculated and axial ratio and tilt angle is computed. The theory is found to be in good agreement with the experimental observations.

Summary of the investigations carried out and comments of the results are presented in the concluding chapter. Description of further work in continuation with this work is also presented. Compared to other existing systems, the present system is not a fixed device. Therefore, it is easy to achieve any desired desired polarization by simply adjusting the flange parameters. Hence, the same system can be used for obtaining a beam with a specific polarization characteristic.

An axially symmetric radiation patterns from a flanged sectoral horn is presented in appendix I. Modified H-plane and E-plane sectoral horn antennas using corrugated flanges are described. Half power beam width and gain are improved with enhanced matching.

Compared to a fixed pyramidal horn the present system offers great convenience in trimming the anthenna characteristics. A technique for improving the coupling between a feed horn and a parabolic reflector is presented in appendix II. It is found that corugated flabges on feed horn may act as "antenna trimmers" for the fine adjustment of different antenna characteristics. Phase modulation of microwave signal using print contact G signal diode is presented in appendix III. The maximum insertion loss of the system is fond to be less than 1 dB. This system can also to used as a continuously variable electronic phase shifter. Phase shift is found to be 80° for current of 12 mA.

## S.P.26. PRAVINKUMAR, P.A.–Synopsis of the Thesis Entitled Modificatios of Secondary Reflector Antenna Patterns due to Shaped Beams from Flanged Primary Horn Feeds–1985– Dr. K.G. Nair

The work presented in the thesis is a report of the efforts made to investigate the effects of shaped primary beams from sectoral horns on secondary reflector antenna. Primary patterns of H-plane sectoral horns are modified by plane and corrugated flanges fitted to the sectoral horns. The reflector is an off-set paraboloid. Experimental results are presented with appropriate theoretical explanation.

Whole work is divided into 6 chapters:

### CHAPTER I: INTRODUCTION

This is the introductory part where the history of the antennas particularly reflector antennas is traced back to the pioneer workers Lodge, Hertz and Marconi. The brilliant exploits of Prof. Hertz in 1886 is described and it is followed by the introduction of different types of reflector antennas. Towards the middle of the Chapter, the description of various types of feeds particularly horn feeds is given. The Chapter ends with a detailed out line of the present work.

### CHAPTER II: REVIEW OF PAST WORK IN THE FIELD

This chapter is a review of the work done in the field of secondary reflector antennas.

The chapter starts with a review of the reflector antennas in general. This is followed by review of papers on reflector antenna feeds. The chapter comes to an end with a detailed review of paraboloidal reflectors which is the topic of research here.

The review covers the time period from 1888 to 1983 in detail. This is conducted in the chronological order and references are given at the end of the chapter.

### CHAPTER III: EXPERIMENTAL SET-UP AND METHODOLOGY

The various equipment used, the experimental set-up and the methodology adopted are discribed in this chapter.

A good part of this chapter is devoted to the various equipment used. The description include the main components like the off-set paraboloidal reflector, flanged sectoral horn feeds and antenna positioner (turn-table). The actual set-up of the experimental arrangement is described.

The chapter comes to a conclusion with a methodology adopted to measure the various antenna parameters like VSWR, on-axis power density, gain, E-and H-plane patterns, half power beam widths and cross-polarisation.

### CHAPTER IV: EXPERIMENTAL RESULTS

This section presents the experimental data and conclusions derived from it. The effect of the corrugated flanged sectoral horns on the VSWR, on-axis power, radiation patterns, gain, half-power beam widths and cross-polarisation of the system is obtained by analysing the experimental data. A large number of curves were plotted and effect of the various modifications on the properties of the system were studied.

In each case, the comparison between the modified and unmodified antenna is made and pros and cons of the modification are evaluated.

### CHAPTER V: THEORETICAL EXPLANATION OF RESULTS

This chapter is dedicated to the theoretical discussion of the modification antenna.

The chapter begins with the detailed theoretical analysis of the corrugated flanged sectoral horn. The modified radiation pattern derived on the basis of line source theory and method of secondary sources of the feed is then applied to derive the secondary pattern of the off-set paraboloidal reflector. The surface current integral method is adopted here.

The computation of the secondary pattern using the resultant expression was carried out and theoretical patterns were derived. Further theoretical calculations by adopting modification of primary feed pattern is suggested to explain the results precisely. A discussion on the limitation of the theory, and practical difficulties in evaluating the final integral expression is also described.

### CHAPTER VI: CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

This is the concluding chapter highlighting the significance of the present work. A number of suggestions for further experimental and theoretical work in this and closely related fields are made at the end of the chapter.

### APPENDIX-I

Design, development and performance evaluation of microwave anechoic chamber constructed as a part of the work to study the radiation patterns of primary horn radiator is described here.

### APPENDIX-II

Effect of corrugated flanges on the radiation pattern of E-plane horns is studied in this section. A simple technique for obtaining identical E-and H-plane patterns from the E-plane sectoral horn is established here Experimental results for a number of horns with flanges of various parameters are presented here.

## S.p.27. BABY, B.V. – Some Non-linear Problems in the Theoretical Physics – 1985 – Dr. K. Babu Joseph

An immense variety of problems in theoretical physics are of the non-linear type. Non-linear partial differential equations (NPDE) have almost become the rule rather than an exception in diverse branches of physics such as fluid mechanics, field theory, particle physics, statistical physics and optics, and the construction of exact solutions of these equations constitutes one of the most vigorous activities in theoretical physics today. The thesis entitled "Some Non-linear Problems in Theoretical Physics" addresses various aspects of this problem at the classical level. For obtaining exact solutions we have used mathematical tools like the bilinear operator method, base equation technique and similarity method with emphasis on its group theoretical aspects.

A new era in theoretical physics was ushered in by the discovery of a non-linear transformation called inverse scattering transform (IST) and the collisional stability of a particular solitary wave solution, called soliton, of a class of NPDEs by Gardner, Greene, Kruskal and Miura [1] and Zabusky and Kruskal [2]. Further rapid development added a number of non-linear field theoretical models such as Korteweg-de Vries (Kdv), two-dimensional sine-Gordon (sG), non-linear Schrodinger, Thirring model etc. The solitary wave solutions of an integrable system are often called solitons [3] which are either topological or nontopological, depending on the nonvanishing or vanishing of the topological charge. Equations such as KdV, sG etc. belong to this class that is characterisd by the existence of an infinite number of conserved quantities. Backlund transformation (BT) constitutes one of the oldest approaches to the solution of NPDEs. The method of prolongation structures has been introduced recently to support the studies using IST and BT.

The bilinear operator method pioneered by Horota [4] is closely associated to the numerical method of Pade approximants. We have applied this method to develop single solitary wave solutions of the Double sinh-Grodon (DshG) equation in (1 + 1) dimensions. The DshG system is a newly introduced system and bears close resemblance to the Louville and the Toda models. For massive and massless $Ø^4$ equations this method yields some previously known solutions.

Non-abelian gauge theories of the Yang-Mills (YM) type are of great interest in contemporary field theory and particle physics, especially in the context of unifield models of fundamental interactions. By using some suitable ansatz one can reduce the SU(2) YM or YM-Higgs theory to non-linear diffrential equations (NDE) (the massless $Ø^4$ equation, or one-dimensional Liouville equation) or to a set of coupled NPDEs. Educlidean space solutions of the massless $Ø^4$equations lead to the celebrated instanton and merons of SU (2) pure YM theory. Monopole solutions of YM-Higgs system can be obtained from the one dimensional Liouville equation or a pair of coupled NPDEs.

We have used the singular solutions of the massless $Ø^4$ model to generate are interpreted as localized fluctuations involving no flux transport. It is conjectured that these objects having infinite action and infinite topological charge, closely resemble the merons and may play a tunnelling role. The idea of employing the soluytions of a know differential equation to construct a solution of a given NPDE was developed by Pinney, Reid anmd Burt [5] who called it the base equation technique. Using this approach we developed multisolitary wave solutions of the DshG system in arbitrary dimensions, which collapse to a single solitary wave in (1 + 1) dimensions.

We have developed a generalisation of the base equation method and called it the composite mapping method, wherein a sequence of maps is applied to several members of the non-linear Klein-Gordon (NKG) family to produce new solutions. In a broad scenario like this where one deals with a whole class of NDEs rather than a specific one, besides yielding new solutions, this procedure can expose certain 'family relationships' between different equations which we later confirmed through the similarity group method. Starting from the classical $\emptyset^4$ equation we have generated through sequential maps, arbitrary dimensional solutions of Liouville, double sine-Gordon (DsG), massive and massless $\emptyset^6$ equations of the NKG family by imposing simple constraints at each stage. While all other known solutions of the DsG collapse to a single wave in (1 + 1) dimensions, our solutions behave differently. Since all the four distinct solutions obtained by us can be simultaneously constructed for given values of a parameter, it will be possible to study their interactions. In this context we have also highlighted the appearance of one set of solutions and the disappearance of another set at a critical point.

The Lie point transformation theory has emerged as a most outstanding attempt to study continuous symmetry, particular solutions and dimensional reduction of NPDE S [6]. When a second order NPDE is invariant under these transformations, known as similarity transformations, it is possible to reduce the number of independent variables by one, and find similarity solutions of the equation [7]. In general the similarity transformations form an extended group, the similarity group, which upon a suitable redefinition of the generators, leads to the Poincare group in the case of Klein-Gorddon (KG) equations. This suggests a three-fold classification of solutions of two dimensional KG equations into translation invariant, heperbolic rotation (boost) invariant and similarity invariant types. Similarity invariance denotes invariance under the full ssimilarity group. Such a description emphasises the behaviour of the solutions rather than that of the equations. Most of the known solitary wave solutions are of the translation invariant type. We have produced rotationally invariant solutions of several NKG equations. The group theoretical meaning of the base equation technique has also been examined. We have found that the similarity groups of the original equation and the constraint equation are identical in all the cases studied in the literature.

It has conjectured that the existence of the Painleve property (PP) (ie., the absence of movable critical points) is a signal to the original equations integrability. We have shown that the translation-invariant sector of the SG equation does not possess PP whereas the rotation invariant sector does possess PP. This may restrict the integrability property of the SG system in some sense.

The SU (2) Yang-Mills field interacting with a Higgs scalar triplet is known to give monopole solutions through the 't Hooft ansatz. Prasad and Sommerfield developed spherically symmetric solutions to this system in a special limit in the static case. Afterwards several attempts based on guesswork were made to obtain time-dependent exact solutions. We have carried out a similarity group analysis of the coupled system of equations representing the SU (2) YM-Higgs model equations and shown that the equations reduce to the one-dimensional form under the full similarity group or under one of its subgroups. This approach gives two new exact time-dependent solutions along with some previously known solutions.

The material reported in the present thesis has been published in the form of the following papers:

1. Solitary wave solutions in double sinh-Gordon system, J.Phys., *A16*, 2685 (1983).
2. Fluctuations in SU (2) Yang-Mills theory, Pramana, *22*, 111 (1984).
3. Composite mapping method for generations of kinks and solitons in the Klein-Gordon family, Phys. Rev. A., *29*, 2899 (1984).
4. Symmetry classification of solutions of two dimensional non-linear Klein-Gordon equations, J. Math. Phys (submitted).
5. Classical SU (2) Yang-Mills-Higgs system: Time-dependent solutions by similarity method, J. Math. Phys. (submitted).

### S.P.28. RADHAKRISHNAN, P.–Nd: Glass laser-induced damage to thin films, two-photon excited fluorescence and plasma studies–1986–Dr. K. Sathianandan.

Laser-induced damage is the principal limiting constraint in the design and operation of high-power laser systems used in fusion and other high-energy laser applications. Therefore, an understanding of the mechanisms which cause the radiation damage to the components employed in building a laser and a knowledge of the damage threshold of these materials are of great importance in designing a laser system and to operate it without appreciable degradation in performance. This thesis, even though covers three distinct problems for investigations using a dye Q-switched multimode Nd:glass laser operating at 1062 nm and emitting 25 ns (FWHM) pulses, lays its main thrust on damage threshold studies on thin films. Using the same glass laser two-photon excited fluorescence in rhodamine 6G and generation and characterisation of a carbon plasma have also been carried out.

The only practical method to determine the most appropriate model of damage in dielectrics is to examine the predictive ability in describing the variation of damage with easily controlled experimental or material variables such as laser pulse width, wavelength and film properties. But in the present experimental investigations, wavelength and pulse width were maintained constant. Analysis of damage has been mainly carried out as a function of the film properties such as refractive index, absorption and thickness. An inverse dependence on absorption and film thickness observed for Spray Pyrolisis Deposited (SPD) and radio frequency (rf) sputtered films in the present investigation gives firm support to the impurity damage model. In the case of damage to transparent polymers the viscoelastic properties play a dominant role.

A comparative analysis of the damage threshold measurements carried out in transparent-conductive coatings have established that spray pyrolysis deposited tin oxide films are also equally good competitors with rf sputtered indium tin oxide films and chemical vapour deposited tin oxide films in high power laser systems as electrodes for electro-optic shutters. Spray pyrolysis technique offers the added advantage of greater flexibility in terms of their electrical and optical characteristics depending on the deposition parameters which in turn depends on damage threshold.

A noteworthy feature of this thesis is the identification of polyacrilonitrile (PAN) films of high damage threshold (26 J/cm$^2$) with very low-level absorption at 1060 nm. Another interesting feature associated with these films is that the damage threshold of these films increases with increase in thickness unlike in the case of dielectrics. This makes these films very good candidates for high energy laser applications.

Various types of attempts are being made to increase the threshold of AR coatings since they are the weakest link in any high power laser system. In the present investigation the threshold of a half-wave layer of Mg $F_2$ films has been shown to increase by about 50% when PAN film having a high threshold was given as an undercoat. The result obtained has been attributed to the change in the chemical environment and to better adhesion of the MG $F_2$ films on PAN.

In the case of investigation on Mg $F_2$ films, the threshold is shown to decrease with increase in film thickness as reported by earlier workers. Low damage threshold obtained in the case of gold films has been explained in terms of the low yeild stress of the material and its high absorptance at 1060 nm. Gold coating with an undercoat of PAN does not show any variation in the damage threshold value which is attributed to the poor adhesion of gold on PAN.

Another important result that has emerged out of the present investigations is the determination of the concentration limit of two-photon excited fluorescence in rhodamine 6G.

## S.P.29. GEORGE PETER–Growth and Characterization of Diammonium Hydrogen Citrate and Citric Acid Monohydrate Single Crystals–1987–Dr. Joy George.

The thesis presents a study of the growth of Diammonium Hydrogen Citrate (DAHC) and Citric acid (CA) monohydrate single crystals from solution and their defect structures. The result of the microindentation and thermal analysis are presented. Dielectric, fractrographic, IR and UV studies of DAHC crystals are also reported.

Large and perfect crystals of size upto (60X27X5) mm$^3$ were grown by slow evaporation in a constant temperature bath. The faces of the grown crystals were identified by angular measurements using goniometer.

Dislocation etch studies have been carried out to asses the perfection of DAHC and CA crystals. Dislocations in DAHC crystals were delienated by propionic acid which was found to be a reliable dislocation etchant for the (OO1) face. Dislocation loops, helices, clusters impurity centers and slip lines are observed with this etchant. The etch pit density is found to be of the order of $1.2X10^2/cm^2$. Other etchants have been tried and formic acid, acetic acid and methyl alchohol were also found to be capable of bringing out dislocations on

the (001) face. The shape of the pit is found to depend on the type of the etchant used. The etch pit formation in DAHC crystals is explained on the basis of the thermodynamic theories of etching. For CA crystals also propionic acid is found to be a good dislocation etchant.

Microindentation analysis of DAHC and CA crystals was done using Vickers pyramidal indenter to study the hardness, toughness, brittleness and the nature of cracks. The hardness of DAHC was found to be 0.68 GPa. The hardness of DAHC was found to be nature of cracks. The hardness with load was analysed upto a load of 12.5 gms. The fracture toughness of DAHC is 0.17 MPa m$^{1/2}$ Loads upto 25 gms were used for the toughness evaluation. The toughness value is found to increase with increase in load in a regular manner. Brittleness of DAHC is found to be 4.04m$^{-1/2}$ Surface removal technique has shown that the threshold crack is radial and originate from the surface. From the indentation studies, hardness of CA was found to be 0.588 GPA. The variation of hardness with load is found to have a minimum around 7.5 gms. The toughness is 0.132 MPa m$^{1/2}$ and the brittleness is 4.48 nm$^{-1/2}$.

The (110) cleavage surface of DAHC exhibit typical examples of hackle structure, Wallner lines and many other interesting crystallographic markings. They are presented and discussed.

Dielectric studies were made on DAHC crystal along the three mutually perpendicular crystals axes in the region of temperature 133 K and frequency 200 to 20,000 Hz. The dielectric permittivity and the loss tangent measurements were made in a low temperature dielectric cell with heating arrangement.

The IR apectrum of DAHC was recorded in the region 4000 - 200 cm$^{-1}$. Absorption bands are observed at frequencies 3400, 3200, 3060, 2860, 1690, 1600, 1330, 1270, 1230 and 1090 cm$^{-1}$ These bands are tentatively assigned to the functional groups in DAHC.

The UV spectrum was obtained in a wavelength range 195 to 500 nm. The only absorption band observed at 210 nm is discussed.

Differential scanning calorimeter was used for thermal analysis of DAHC and CA crastals. The measurements were made from room temperature upto the melting of these crystals. The calorimeter traces obtained for DAHC and CA are presented and discussed.

## S.p.30. AJITH KUMAR, C.M.–Studies on Magnetic Monopole Solutions of Non-abelian Guage Theories and Relatedd Problems–1987–Dr. Babu Joseph.

In 1931 Dirac studied the motion of an electron in the field of a magnetic monopole and found that the quantization of electric charge can be explained by postulating the mere existence of a magnetic monopole. Since 1974 there has been a resurgence of interest in magnetic monopole due to the work of 't Hooft and Polyakov who independently observed that monopoles can exist as finite energy topologically stable solutions to certain spontaneously broken gauge theories. The thesis, "Studies on Magnetic Monopole Solutions of Non-abelian Gauge Theories and Related Problems", reports a systematic investigation of classical solutions of non-abelian gauge theories with special emphasis on magnetic monopoles and dyons which possess both electric and magnetic charges. THe formation of bound states of a dyon with fermions and bosons is also studied in detail.

The thesis opens with an account of a new derivation of a relationship between the magnetic charge of a dyon and the topology of the gauge fields associated with it. Although this formula has been reported earlier in the literature, the present method has two distinct advantages. In the first place, it does not depend either on the mechanism of symmetry breaking or on the nature of the residual symmetry group. Secondly, the results can be generalised to finite temperature monopoles.

We have carried out a systematic search for solutions of the nonlinear radial field equations of the 't Hooft-Polyakov monopole theory by using the direct method of Hirota. We have applied this method to the second order nonlinear differential equations corresponding to a vanishing Higgs self-interaction and reproduced all the previously knwon solutions which satisfy the first order Bogomolny equations.

A pair of exact, complex conjugate solutions is constructed for SU(2) gauge theory in the Prasad-Sommerfield limit. The Euclidean actions corresponding to these solutions are found to be finite and complex. These flat-space solutions are transformed to de Sitter space by a standard procedure.

We have constructed new time-dependent solutins to pure SU(2) gauge theory which are related to monopoles and dyons. Another set of solutions, which approaches a singular dyon configuration are also obtained. All the solutions are singular at the origin and hence the corresponding actions are infinite. In both cases, owing to the infiniteness of action, semiclassical approximation cannot be directly applied to extract more physical content. However, their Euclidean time development is interesting.

In the final section of the thesis we carry out a study of the bound states of spin 1/2 and spin zero particles in the background field of a point dyon for isospinor and isovector representations. Energy levels and eigen-functions for all angular momenta are obtained for isospinor fermions, isospinor bosons and isovector bosons. For isovector fermions bound state spectrum for lowest angular momentum is determined. The method of separation of angular and radial parts is achieved by using spherical harmonics. This method is compared with an alternative method of separation using monopole harmonics, and the two methods are shown to be equivalent. A relation connecting monopole harmonics and spherical harmonics is also derived. The study of the bound states of monopoles and dyons is important for their possible experimental detection.

### S.p.31. PRADEEP, B.–A study of the preparation and characterization of Bismuth Telluride and Bismuth Oxide Thin Films–1987–Dr. Joy George.

In this thesis is reported the preparation and characterization of $Bi_2Te_3$ films. The bismuth and tellurium flux are approximately 2-3 × $10^{14}$ atoms $cm^{-2}S^{-1}$ and 3-4 × $10^{15}$ atoms $cm^{-2}S^{-1}$ respectively. The substrate temperature is in the range 530-545 K. X-ray diffraction studies have shown that these films have no particular orientation on the substrate surface. Electrical measurements show that the films have carrier concentration of 1.2 × $10^{20}$ electrons $cm^{-3}$ and a mobility of 100 $cm^2v^{-1}S^{-}$. Thermoelectric power measurements show that these films have a high thermoelectric power of 350 V $K^{-1}$

A systematic study of the oxidation of bismuth films in different atmospheres like air, super-heated steam, nitrogen, and partial vacuum has been undertaken. The temperature of oxidation is varied from 500 K to 650 K. x-ray diffraction studies have been made of the different films prepared and the different single phase films of $\beta$-$Bi_2O_3$ (tetragonal), $\alpha$-$Bi_2O_3$ (monoclinic), and $\gamma$ -$Bi_2O_3$ (cubic) obtained have been confirmed.

Three temperature method was also used here for the preparation of $Bi_2O_3$ films. Here bismuth is evaporated into an oxygen atmosphere. The impingement rate of bismuth atoms into the substrate surface is varied from 3.5 × $10^{15}$ to 5.6 × $10^{15}$ atoms $cm^{-2}$ $S^{-1}$. The substrate temperature is also varied from room temperature to higher temperatures. Only $\beta$-phase films are obtained by this technique.

Films of $Bi_2O_3$ obtained by three temperature method is of poor quality due to the incorporation of unreacted bismuth in the growing film. Good quality films have been obtained using activated reactive evaporation. As evidence by the x-ray diffraction studies it is seen that at constant oxygen pressure, for low bismuth evaporation rate, $\beta$-$Bi_2O_3$ and at high evaporation rate $\alpha$- $Bi_2O_3$ are obtained. Refractive index, absorption coefficient, and band gap of these films have been determined from the study of optical properties.

Heat mirrors using layers of $Bi_2O_3$ and gold has been fabricated. Visible transmission and IR reflection have been optimized by varying the thickness of $Bi_2O_3$ and gold layers. These structures can be used incandesent lamps, where it will increase the efficiency and in glass panes and windows of buildings where it will give better insulation.

### S.p.32. JAYALEKSHMI, S. – An Investigation on the Electrical and Optical Properties of Certain Plasma Polymerized thin Films and Evaporated $V_2O_5$ Films–1987–Dr. M.G. Krishna Pillai.

The work presented in the thesis comprises of the preparation and properties of certain plasmapolymerized thin films and electron beam gun evaporated $V_2O_5$ thin films. Plasma polymerization has been carried out both in R.F. and D.C. glow discharges. In the R.F. plasma monomer Citral was polymerized and the electrical and dielectric properties were investigated. A D.C. discharge plasma was employed to polymerize thiophene. With the intention of comparing the polymer dielectric film with an oxid dielectric film, $V_2O_5$ thin films were prepared by electron beam gun evaporation method and their dielectric properties investigated.

The films obtained by polymerizing Citral in the R.F. plasma, showed exceptionally high voltage stability and excellent thermal and chemical stability. A 5000°A thick polymer film was found to withstand more than 1000 volts without any sign of breakdown. For polycitral films the electrical conductivity, dielectric loss, temperature coefficient of dielectric constant and percentage variation of dielectric constant with frequency were also found to be low. The observed dielectric properties were found to be comparable to those of the best known insulators. These offer the possibilities for applying polycitral thin film as the insulating material in high voltage thin film capacitors.

$V_2O_5$ thin films were prepared by the electron beam gun evaporation technique. The electrical conductivity and dielectrical properties of the films were investigated.

The d.c. electrical conduction mechanism was explained on the basis of ionic motion due to oxygen vacancies in the film structure. Compared to polycitral films thermal stability and dielectric strength were found to be lower for $V_2O_5$ films. But the value of the dielectric constant was four times higher than that for polycitral films. Loss value was also higher for $V_2O_5$ films due to the presence of dipoles arising from defects and vacancies in the film material.

The interesting outcome of the investigations on $V_2O_5$ thin films was the observation of switching and memory effects in A1-$V_2O_5$-A1 sandwich devices. A change over from the OFF state (low impedance state) to the ON state (high impedance state) was observed when the voltage applied to the devices exceeded a threshold value. The devices could be switched back from the ON state to the OFF state by the application of suitable pulse voltages. The details of the investigations on the memory switching effects of $V_2O_5$ films are included in the thesis as an Appendix.

The polymer films obtained by carefully polymerizing the monomer thiophene in a D.C. discharge plasma showed conductivity in the semiconducting range. The absorption spectra of the polymer films were investigated in the UV-Visible and IR regions. The refractive index, absorption coefficient and optical band gap were determined. A possible mechanism of polymerization and a probable structure for the polymer were arrived at on the basis of IR investigations.

Photoconductivity studies on polythiophene films were carried out over a wide range of wavelengths. The results indicated the prospects of using polythiophene as a promising organic photovoltaic material. The opto-electronic measurements carried out include the variation of photoconductivity with temperature of the film as well as wavelength and intensity of illumination.

It was found that by varying the polymerization conditions the bandgap of the undoped polymer could be varied over a wide range. This shows the prospects for many intersting future results and a variety of new applications.

## S.p.33. PALSON, T.I.-Investigations on the Preparation and Properties of Reactivity Evaporated Lead Sulphide and Tin Telluride Thin Films-1987-Dr. Joy George.

IV-VI compounds such as sulphides, selenides and tellurides of lead and tin and their alloys have attracted much attention for a long time. Suitably prepared polycrystalline films of lead salts have been used as photoconductive detectors in the near infrared. More recently solid solutions of SnTe in PbTe, and SnSe in PbSe have been used to construct photoconductive and photovoltaic detectors for longer wavelengths. The construction of p-n junction injections lasers of lead salts, and of solid solutions with their tin analogs has been an important technological development.

The work reported in this thesis is the preparation and the structural, electrical and optical properties of reactively evaporated lead sulphide and tin telluride thin films. The three temperature method had been used for the preparation of these semi conductor thin films. In this preparation technique constituent elements are evaporatedd from separate sources with the substrate kept at a particular temperature. When one of the constituent element is a gas near room temperature, the method is often called reactive evaporation. It has been found for many materials that a stoichiometric interval exists with a limited range of flux and substrate temperature. Usually this technique is used for the preparation of thin films of high melting point compounds or of materials which decompose during evaporation. Tin telluride and lead sulphide are neither high melting point materials nor do they decompose on melting. But even then reactive evaporation offers the possibility of changing the ratios of the flux of the constituent elements within a wide range and studying its effect on the properties of the films.

A variety of physical and chemical deposition techniques have been developed for the deposition of thin films of lead sulphide. Nobody has yet reported the preparation of PbS thin films by the reactive evaporation technique. Stoichiometric as well as sulphur rich films can be prepared by this technique. To get stoichiometric films the sulphur source was baffled, so that the sulphur vapour beam did not strike the substrate as such. The number of sulphur molecules striking the substrate surface per unit area in unit time in this case will be that due to the partial pressure of the sulphur vapour in the chamber. In the case of sulphur rich films, the sulphur source was not baffled and more sulphur molecules will strike the substrate surface.

It has been found that the following parameters give good stoichiometric films of PbS:

Pb atom flux : $1.3 \times 10^{15}$ to $2.6 \times 10^{15}$ atoms $cm^{-2}S^{-1}$
$S_2$ molecule flux : $2.2. \times 10^{16}$ to $1.1 \times 10^{17}$ molecules $cm^{-2}S^{-1}$
Substrate temperature : 300 - 650 K.

Unless otherwise stated lead sulphide films refer hereafter to stoichiometric lead sulphid films. X-ray diffraction studies of the PbS films indicated that films preparedd below the substrate temperature of 325K were amorphous in nature. As the substrate temperature was increased polycrystalline PbS films were obtained. Further increase in the substrate temperature gave a preferredd orientation to the grains with (100) planes parallel to the substrate surface.

Electrical measurements were made and d.c. conductivity, Hall mobility, carrier concentration and thermoelectric power were studied in the temperature range 100 - 400 K on polycrystalline films prepared at different substrate temperatures. Hall effect measurements showed that the films obtained were p-type. A typical PbS film prepared at 400 K had a carrier concentration of $6 \times 10^{17}$ $cm^{-3}$ and Hall mobility of 30 $cm^2$ $V^{-1}S^{-1}$ at 300 K. Thermoelectric power was high as 500 V/K at 300 K. This is around 1.7 times the single crystal value. Films prepared at substrate temperature 600 K gave a maximum mobility of 125 $cm^2V^{-1}S^{-1}$ at 300 K.

Amorphous films of PbS had been characterised optically and electrically. Optical characterisation showed that amorphous PbS films had an optical band gap of 1.6 eV and a refractive index of 2.5. Crystalline PbS is having a bandd gap of 0.39 eV and refractive index of 4.5. This large deviation was explained in terms of the difference in coordination of the amorphous and crystallne environments. Sulphur rich amorphous PbS films had a still higher optical band gap of 1.8 eV and show no optical absorption before the onset of band to transitions, whereas stoichiometric amorphous PbS films showd an absorption which was decreasing with the photon energy before the onset of band to band transition.

Electrical measurements of amorphous PbS films showed a room temperature resistivity of $1.7 \times 10^4$ ohm cm. The films crystallised when heated beyond 330 K and the resistivity of the films decreased by three orders of magnitude. sulphur rich amorphous films were more resistive ( $4 \times 10^6$ ohm cm) and these films crystallised at aroun 330 K and resistivity dcreased by five orders of magnitude.

SnTe films were usually prepared from p-type SnTe ingots prepared by fusing stoichiometric proportions of Sn and Te. In the work reported here, SnTe thin films were prepared for the first time by the three temperature method to avoid incongruent evaporation from a single source and the consequent lack of stoichiometry.

It had been found that good stoichiometric films of SnTe were obtained with the following parameters:

tin flux = $4.1 \times 10^{14}$ to $2.4 \times 10^{15}$ atoms cm$^{-2}$S$^{-1}$

tellurium flux = $7.4 \times 10^{15}$ to $2.2 \times 10^{16}$ atoms cm$^{-2}$S$^{-1}$ substrate temperature = 568 - 598 K.

The structural characterisation of these films were done by x-ray diffraction technique. These films had grains oriented such that (111) planes were parallel to the substrate surface. Optical micrographs of the films before and after annealing showed that annealing at the preparation temperature had no effet on the grain size. The temperature dependences of the electrical conductivity, the Hall coefficient and Hall mobility of these films were studied in the temperature range 100 - 450 K. As prepared thin films of SnTe, had got the following electrical characteristics at room temperature:

Conductivity $6.5 \times 10^3$ (ohm cm)$^{-1}$
Hall coefficient $1.55 \times 10^{-2}$ cm$^{-3}$ coulomb$^{-1}$
Hall mobility 100 cm$^2$V$^{-1}$S$^{-1}$

The effect of annealing on the electrical properties had also been investigated. The carrier concentration and conductivity decreased after annealing whereas the Hall mobility increased.

Due to the low chemical diffusion constant of tin, which results in the freezing of the equillibrium tin vacancy concentration, SnTe is always a p-type extrinsic semiconductor. Because of the heavy carrier concentration and the consequent repulsion between the cariers the mobility of charge carriers in SnTe films are low. The mobility can be increased by reducing the carrier concentration. This can be achieved by filling the tin vacancies by an appropriate cation which is having a high mobility in the SnTe matrix. It has been possible to obtain mobilities better than 1000 cm$^2$V$^{-1}$S$^{-1}$ at room temperature by doping SnTe films with germanium.

A setup for testing IR detectors had been fabricated and is also reported in this thesis. A cell which could be evacuated and cooled to LN$_2$ temperature with provisions for detector mounting and illumination had been fabricated as part of this setup. A ligh chopper also was designed and fabricated in house, for this purpose. This chopper can produce light pulses from 10 Hz to 2000 Hz using two chopping blades and had an accuracy better than 0.1% and negligible temperature drift.

## S.p.34. SATHEESH KUMAR, M.K.–Title of the thesis: Photoacoustic effect: Some applications in laser technology –1988–Dr. C.P. Girijavallabhan

The thesis presents a detailed account of the investigation carried out in the area of Photoacoustic (PA) technique and an extensive version of its instrumentation. It contains many examples in which simple measuring techniques based on PA effect have been effectively utilised for different types of studies associated with laser technology. One of the important work presented is the design and fabrication of a laser power méter based on PA effect. This laser power meter is capable of detecting all wavelengths from near ultraviolet to far infared region. Subsequently a measuring range from 5 w to 10 w is obtained which represents a considerable improvement over similar devices reported earlier. This set up has been successfully employed in the laser attenuation measurement in the atmosphere using a He-Ne laser. From the result it is found that the pollution is maximum at 2 am in Cochin University campus.

Similarly PA studies have been extended to study the thermal diffusivity of Copper and CeO$_2$ films for different thicknesses and this method offers a promising tool for the precise measurement of thermal parameters of such samples. These studies in fact revealed the possibility of identifying the thermal parameters associated with dielectric materials which are needed for the development of high quality optical materials for laser systems.

A current stabilised CW CO$_2$ laser has been designed and fabricated. It essentially consists of two wafer cooled plasma tubes of lengths 75 cm each are optically in series but electrically in parallel. Solid state circuitry is employed for current stabilisation and control. Stabilised CW laser beam in the 10.6 m region upto 30 Watts is available from this system. Parametric studies of the current regulated CW CO$_2$ laser have been carried out using a potoacoustic laser power meter. The detailed study of variation of laser power with plasma tube current levels at a fixed gas pressure gives the parametes for optimising the operating conditions. It is found that the additon of water vapour at 0.3 torr improves the power level beyond 30 W.

This CO$_2$ laser has been successfully employed for material processing in silicon wafers. The optical transmission through this wafer is measured as a function of time using the photoacoustic laser power meter. It is observed that the transmission coefficient decreases with the time and in 10-15 seconds it reaches a steady value. Thus the absorption coefficient could be determined at this temperature from which the free carrier concentration in an intrinsic semiconductor is accurately calculated.

## S.p.35. REGHUNATH, A.T–Studies on Optical Attenuation in Sea Water Using Dye Laser and Laser Propagation in a Turbulent Medium–1988–Dr. V.P.N. Nampoori.

With the advent of lasers, there has been a revived interest in the field of under water optical systems. Lasers, because of their low divergence, narrow bandwidth and high power are identical sources for under water optical communication, ranging and photography. In order to develop any under water optical system, the region of minimum attenuation of light in water must be identified. The search for an optical window demands an extensive study of the transmission characteristics of sea water for different wavelengths in the visible region. The sea water constituents are of two types; the dissolved salts which are mostly in ionic state and the suspended particules such as organic matter and dust. The dependence of optical attenuation on the concentration of these constituents is an essential scientific information to be gathered. the sea water being in random turbulent motion, the laser propagation in a turbulent medium is also a related area of importance. The variations in the temperature and salinity of sea water will give rise to variations in the refractive index of the medium. Even though the refractive index variation from the mean value is small, in a situation of practical interest, a propagating laser beam encounters a large number of inhomogeneties resulting in a significant cumulative effect. The central theme of the work presented in the thesis is a careful investigation of the factors influencing the attenuation of laser beams through sea water.

The thesis presents a detailed report of the work done by the author on the attenuation studies in sea water and some effects of turbulent medium on laser propagation. The thesis contains six chapters. The first chapter gives an introduction to the subject of laser propagation through sea water. A review of the earlier work on attenuation studies in water is included in this chapter. The theoretical background of the problem of laser propagation through a turbulent medium is summarized in the last part of this chapter.

Chapter II gives the fabrication details of a nitrogen laser pumped dye laser used for the attenuation studies in sea water. For the dye laser, a holographic grating is used in grazing incidence. The laser gives 3 ns pulses of 0.04 nm line-width. Using different dyes, the laser is tuned from 425 nm to 630 nm. The parametric studies of the dye laser which form an important part of the required instrumentation are also reported in this chapter.

The experimental set up for the attenuation measurements is described in chapter III. The split-pulse laser method is adopted using a nitrogen laser pumped dye laser as the source. The laser pulse is split into two by a beam splitter; one part of which goes through a 20 cm long reference cell and the other part goes through a 500 cm long sample cell. The pulses are reflected back by the mirrors kept at the end of these cells and are detected by a photodiode. The advantages of this technique over other high sensitive absorption measurement methods are described in this chapter.

In chapter IV, the results of attenuation studies in distilled water, 'synthetic' sea water and natural sea water are described. Several authors had reported the attenuation coefficients of distilled water. But these values are found to differ by a factor of 2 owing to the low value of attenuation coefficient coupled with several experimental corrections required to arrive at the final experimental result. Hence the optical attenuation in distilled water is re-investigated using the present set up.

Attenuation studies of sea water form a major part of this chapter. In order to determine the effect of dissolved constituents of sea water on attenuation, the measurements are conducted in 'synthetic' sea water prepard by dissolving the respective chemicals in the right proportion in doubly distilled water. Two samples of synthetic sea water are studied. The first sample contains only the major constituents and the second sample contains the major and minor constituents. The nature of attenuation curves are found to be similar to that of distilled water. It is concluded that the presence of minor constituents in the present concentration levels has negligible effect on optical attenuation. The details of sample preparation, experimental procedure and results are reported.

The results of the studies on two samples of natural sea water are reported in the last part of chapter IV. The two samples collected from the Arabian sea are – one from 3 Km. off the coast and the other from 30 Km. off the coast. These samples are filtered using whatman grade 1 filter paper to remove large scale suspended particles. The attenuation in natural sea water was found to be much higher than that for synthetic sea water. The chemical composition of both being almost same, the high value of attenuation coefficient of natural sea water is concluded to be due to the presence of suspended particles. The sample collected from 3 Km. off the coast showed very high attenuation indicating the increased effect of suspended particles.

Chapter V describes the details of the experiment on the laser propagation through a turbulent medium. Experiments are conducted in a laboratory simulated turbulent medium. The laser propagation characteristics through the simulated turbulent medium, are studied using a He-Ne laser. The fluctuations in the intensity of the propagated laser beam are detected and recorded in a data logger. The change in the variance of log-intensity with the propagation length shows a saturation behaviour, as reported for the case of atmospheric turbulence. The power spectrum of the irradiance fluctuations shows a-5/3 power law behaviour, in agreement with the Kolmogorov-Obukov model turbulence for the atmosphere. From the observations, it is concluded that the laboratory simulated turbulence, behaves similar to the atmospheric turbulence. The probability distribution function for the weak turbulence and the strong turbulence are suggested.

A new method of qualitative characterising the hydro-dynamic turbulence is proposed in this chapter. The time series obtained from the fluctuating intensity measurements is Fourier analysed to obtain the $a_n$ and $b_n$ coefficients. The points $R_n$ obtained from these values are plotted in $(a_n, b_n)$ space. Trajectories in the Fourier space show certain characteristics, depending on the strength of the turbulence. It is also found that the phase space trajectories will characterise the turbulence qualitatively.

Quantitative characterisation is also done by K entropy method. The values of K entropy gives a quantitative picture of the strength of turbulence averaged over the path.

Chapter VI gives the general conclusions drawn from the results reported in the earlier chapters. There is no well defined optical window for sea water. However, because of the high scattering loss in the blue region and high absorption in the red region, there is a broad minimum for the attenuation at around 500 nm. It is further concluded that the attenuation of sea water essentially depends on the amount of suspended particles present. The dissolved constituents have lesser effect on the attenuation. The behaviour of the fluctuations in the intensity of the propagated laser beam, due to the variation in the temperature of the water medium is similar to that in the case of the atmosphere. The major difference between the two cases is in the time scales in which the fluctuations occur.

## S.p.36. AMBIKA, G.–Studies on the universal parameters and onset of chaos in dissipative system–1988–Dr. K. Babu Joseph.

The thesis work is mainly centered on the asymptotic behaviour of nonlinear nonintegrable dissipative dynamical systems. It is found that such systems exhibit random behaviour or chaos. The nature of the onset of chaos and the statistical description of the chaotic state are fascinating fields of study. One of the mechanisms for onset of chaos in many systems is the period doubling bifurcations. This route to chaos is characterised by a universal behaviour described by two universal indices viz. the bifurcation rate and the scaling factor ∝ as well as the universal function g(x). These are usually computed numerically.

The thesis reports a new analytic algorithm developed using a perturbative scheme to compute∝, and g (x) for general one hump maps of the form $x_{n+1} = 1 - a \times n^z$ where z is the order of the local maximum. For a given z, it is possible to carry out the calculations to any order of accuracy. However the perturbative series is not highly convergent but asymptotic in nature and so the use of Pade approximants is found to give reliable results. When z is not an integer, but $z = z' \pm \epsilon$ with z' the integer nearest to z, the expressions for ∝ and can be expanded in powers of E + vc............

At the accumulation point of the bifurcations $a_\infty$, the iterates of g(x) form a nearly self-similar Cantor set. The first three dimensions $D_0$, $D_1$, $D_2$ of this set are computed using our method and their variation with z is studied.

The latter part of the thesis deals with investigations on the onset of chaotic behaviour in a driven pendulam with van der Pol like dissipation. We apply Melnikov criterion to predict the onset of chaos in this system, followed by a detailed numerical analysis. We observe that at low frequencies, the system has a strange attractor while at medium frequencies, the limit cycle develops a stochastic band. Inside the band, subharmonic bifurcations can be observed. The effect of an additive white noise in this system is to wash out the random nature to some extent, although the approach to chaos is accelerated by noise.

### S.p.37. Abdul Rasheed, T.M.–Laser induced thermal lens and near infrared absorption studies of CH overtones in some organic compounds–1988–Dr. V.P.N. Nampoori

With the advent of laser technology and parallel developments in detection techniques, research in spectroscopy has attained new dimensions. Measurement of weak absorptions arising from vibrational overtone and weakly allowed electronic transitions is one such area. Two optothermal techniques namely photoacoustic and thermal lensing are now-a-days used to detect such weak absorptions. Vibrational overtone spectroscopy of X-H (X = C,N,O) containing molecules is an area of considerable interest and both the above mentioned exxperimental techniques are being used for overtone spectroscopy. The following specific reasons are seen as the motivation for the interest in X-H overtone spectroscopy. (1) It is recognised in the study of nonradiative electronic relaxation processes that highly excited vibrational levels in the ground electronic state actively participate in the intramolecular energy relaxation. (2) The conventional normal mode description, which is widely and successfully used to describe fundamental molecular vibrations fails to provide a satisfactory description of the very anharmonic overtones. One can in principle introduce anharmonic coupling terms in the Hamiltonian and can predict the overtone spectra. But such an approach is shown to predict complicated spectral features, and is contrary to what is experimentally observed. This led to the introduction of the local mode model for describing the highly excited vibrational states of X-H containing molecules. (3) An understanding of highly excited vibrational states is an essential part of the development of a satisfactory theory of multiphoton photochemistry. (4) The spectroscopic and theoretical studies of highly excited vibrational levels are concerned with the excitation of chemical bonds to a significant fraction of their bond dissociation energies. Thus they provide an important link between spectral properties and chemical reactivity.

This thesis presents a detailed account of the work done by the author during the past few years in the Department of Physics, Cochin University of Science and Technology. The main experimental work that has been carried out is the setting up of a dual beam cw laser induced thermal lens spectrometer and measuring the fifth CH overtone spectra of several liquid phase organic compounds. The overtone transitions are very weak in intensity compared with the fundamental transitions (the fifth overtone transition being a million times weaker than that of the fundamental) and the recording of such spectra requires high sensitivity experimental techniques, important among them are thermal lensing and photoacoustic detection. Of these the thermal lens technique is ideal for liquid phase measurements [2] which has been used for the present studies.

The experimental set up uses a Rhodamine 6G dye laser pumped by an Argon ion laser. The pump beam (50-100 mW) chopped at a low frequency (10-25 Hz) causes a time dependent thermal lens resulting from the fluctuating index gradient within the sample. A probe He-Ne laser beam passing collinearly through the sample gets modulated by this fluctuating thermal lens. The strength of the modulation depends on the absorptivity of the sample at the particular pump wavelength. Also, this signal is linear in pump power for moderate power levels. The signal is detected in the far field from the sample using a PMT fitted with a He-Ne laser line filter and pinhole. The output of the PMT is synchronously detected using a lock-in amplifier. Scanning the dye laser and power normalizing the lock-in signal yields the overtone absorption spectrum.

The experimental configuration used in the present study is a modified version of the configuration used by Swofford et. a1 [ ]. The modifications were made to suit the present set up and also to obtain certain advantages over the earlier work of Swofford. For successful measurement of the extremely weak overtone transitions, several important experimental considerations are required. The present experimental set up takes into account all these factors.

While the spectra in the fifth overtone ($\Delta V = 6$) region are obtained by the thermal lens technique, the spectera upto the fourth overtone regions ($\Delta V = 2-5$) are recorded in a Hitachi Model 330 UV-VIS-NIR spectrophotometer. It is to be pointed out that even the fourth overtone ($\Delta V = 5$) is extremely weak to be recorded in spectrophotometers and the fifth overtone necessarily requires high sensitivity techniques such as the thermal lens spectroscopy.

The overtone data from $\Delta V = 2$ to $\Delta V = 6$ obtained by the conventional near infrared and the high sensitive thermal lens spectroscopic technique are analysed using the local mode model. The model treats a molecule as a set of uncoupld anharmonic oscillators. For the X-H oscillators belonging to a common X atom, coupling terms are introduced in the local mode Hamiltonian. The two parameters which charaterise a local mode are the mechanical frequency and the anharmonicity. These parameters are very sensitive to the type of the oscillator, environment, conformation stats and steric interferences.

The spectroscopic and structural information obtained from the near infrared and thermal lens spectroscopic studies of CH ovetones recorded here in some organic compounds are summarised below.

### i) 1, 2-Dichloro and Dibromo ethanes

The near infrared overtone spectra of liquid phase 1, 2 dichloro and 1, 2 dibromo ethanes in the spectral regions of $\Delta V_{CH}$ = 2-5 are studied. The observed spectral features are assigned using the local mode model. Local mode frequencies and diagonal local mode anharmonicities are obtained from an analysis of the spectra. The local-local combinations observed are interpreted on the basis of a coupled CH oscillator model Hamiltonian. Local normal combinations show complex structures and their possible assignments are also given.

### ii) Acetophenone and Benzaldehyde

Overtone spectra of Acetophenone and Benzaldehyde in the visible and near infrared regions are studied by the dual beam thermal lens and conventional absorption techniques respectively. The observed increase in the mechanical frequency of aryl CH bonds from that of benzene is attributed to the decrease in aryl CH bond length caused by the electron withdrawing property of the substituents. It is also shown that the main influence arises from the carbonyl group in the substituents. Overtone spectra also demonstrate that acetophenone contains two types of methyl CH bonds arising from the anisotropic environments created by the oxygen lone pair and carbonyl $\pi$ electron interactions. The local mode parameters of the two types of methyl CH modes are compared with those of acetone and acetaldehyde reported by other workers earlier. The possible factors influencing the methyl CH bonds in acetophenone are discussed.

### iii) 2-Butanone

The near infrared absorption spectrum of liquid phase 2-butanone in the overtone regions $\Delta V = 2 - 5$ is studied. The main peaks observed in the spectrum are assigned to pure overtones of the methyl group away form the carbonyl group. This methyl group is shown to maintain $C_{3v}$ symmetry. The calculated peak positions of the overtone spectrum using $C_{3v}$ local mode Hamiltonian agree with the observations. It is also shown that the overtones of the out-of-plane $CH_b$ bonds of the adjacent methyl group are coincident with the overtones of the independent methyl group, while the overtones of the in-plane $CH_a$ bond are on the high energy side.

### iv) Styrene and Polystyrene

The vibrational overtone spectra of styrene (liquid) and polystyrene (solid) are studied in the visible and near infrared regions using dual beam thermal lens and conventional absorption techniques respectively. A local mode analysis of the spectra has shown that the prominent absorption bands in both the compounds are aromatic CH overtones. The local mode parameters of the two compounds are found to be close to those of benzene. For polystyrene, the overtones of the $Sp^3$ CH bonds appear on the low energy side of the aryl CH overtones. This work presents the first thermal lens overtone observation in a polymer. This is also the first thermal lens overtone study in a solid.

### v) Trichloroethylene

As a good candidate containing a single CH oscillator, the overtone spectrum of trichloroethylene in the visible and near infrared regions are studied using thermal lens and conventional methods respectively. A high value of the mechanical frequency is observed relative to that in ethylene, which arises from the electron withdrawing property of the halogen atoms. The fifth overtone energy value is used to predict the change in CH bond length from that in ethylene. The $\Delta V = 3$ region shows Fermi resonance between pure overtone and stretch-bend combination states. The magnitude of the Fermi interaction matrix element is deduced from an analysis of the spectrum.

### vi) Monochloro and Monobromo benzenes

The fifth overtone spectra of these compounds detected by pulsed thermal lens and conventional absorption were reported earlier by other workers. We have reinvestigated these spectra using the cw dual beam thermal lens technique. The physical mechanism of CH bond strengthening resulting from the halogen substituents is also proposed.

Thus the present overtone spectroscopic studies using laser induced thermal lens and conventional absorption techniques have yielded several spectroscopic and structural details of the molecules studied.

## S.p.38. RAMACHANDRAN, T. – Development of a nitroigen laser pumped dye laser with a single stage amplifier and studies on energy transfer dye laser systems – 1988 – Dr. K. Sathianandan

Pulsed uv lasers and tunable dye lasers pumpd by them find important applications as sources for various experiments in spectroscopy, solid state physics, chemical physics and medicine. As the experiments advance to higher sophistication, the demands on the laser characteristics such as power, pulse width, stability and repetition rate become more stringent. The present thesis reports the work carried out by the author on the design, fabrication and optimisation of a high power nitrogen laser and a tunable dye laser with an oscillator-amplifier configuration. The studies also include applications of the above lasers to the investigations on solvent effects of Rhodamine 6G dye laser, energy transfer studies on mixed dye systems and radiative decay characteristics of $Ho^+_3$ ions in $CaF_2$ lattice. The above problems have direct applications on laser physics itself; since studies on solvents and mixed dye systems can lead to better designs of active media for dye lasers. Also, since $CaF_2$. $Ho^{3+}$ is one of the few solid state materials having laser transitions in green region, considerable importance is attached to its detailed study. The investigations outlined above are presented in seven chapters.

The first chapter begins with a historical survey on the various designs of nitrogen lasers followed by a brief analysis of the theoretical considerations for laser action in nitrogen gas. It is shown that a very fast excitation of nitrogen molecules is a pre-requisite for population inversion. This is accomplished by a fast electrical discharge which dictates a very low impedence pulse circuit. A Blumlein circuit with transverse excitation is ideal for this, since with a moderate voltage it is possible to excite the gas at high pressures. Details of how a Blumlein circuit can be incorporated into a nitrogen laser is given. A comparison with other types of discharge circuits is also presented.

mixtures in place of a single dye, the efficiency is enhanced. The donor and acceptor concentration ratio at which there is maximum efficiency is identified. An attempt has also been made to analyse the exact nature of the energy transfer mechanism in mixed dye systems.

Chapter seven presents the results on the calculation of relative values of non-radiative transfer efficiencies from different upper levels to the 5 $S_2$ level of $Ho^{3+}$ green emission (551.2 nm) in $CaF_2.Ho^{3+}$. The calculation is made using the data available from the excitation, absorption and fluorescence spectra.

## S.P.39. - RAVISANKAR, M. Fabrication and Parametric Studies of a Triggered Nitrogen Laser and Investigations on the Influence of Dissolved Constituents of Sea water on the Optical Attenuation Using the Nitrogen Laser Pumped Dye Laser - 1989 - Dr. K. Sathianandan.

Optical attenuation study in sea water has assumed renewed interest because of its importance in the emerging areas of underwater applications such as optical communication, imaging, target finding and ranging. In recent years, many workers have carried out optical attenuation studies in clear water, "artificial" sea water and natural sea water by laboratory and in situ methods. A careful examination of the available information on sea water reveal that reliable data are not available. In addition, there are major disagreements among the results that are reported. The reasons for such discrepancies can be attributed to the differences in the composition of the sea water and to the experimental methods and procedures adopted by the various investigators. Therefore, to get reliable data, a systematic analysis of the effect of the dissolved constituents of sea water on optical attenuation has to be carried out using an experimental technique which takes care of all the possible errors. The present thesis contains the details of the work done by the author in this direction.

The material presented in the thesis can be broadly divided into two sections. The first section covers the fabrication details of a nitrogen laser which is used to pump a dye laser. The second section gives the optical attenuation studies of different solutions containing the constituents of sea water.

Chapter one is a general introduction to the nitrogen laser, nitrogen laser pumped dye laser and optical attenuation studies in sea water. A comprehensive review of the work on optical attenuation studies is presented here as a necessary introduction to the detailed investigations undertaken.

A continuously tunable dye laser has to be used for the determination of optical attenuation in the entire visible region. In order to get nanosecond pulses, which is required in the present experimental technique, the dye laser has to be pumped by a nitrogen laser. A pulsed nitrogen laser of about 500 kW and a repetition rate of 50 pps (maximum) is fabricated to suit the requirements. Design and fabrication details of this nitrogen laser are included in the second chapter of the thesis. Efficiency of the nitrogen laser has been improved by using a modified design of the spark gap and the trigger circuit. Trigger repetition rate can be selected as 10, 25 and 50 pps.

Parametric studies of the nitrogen laser were carried out and presented in the third chapter of the thesis. Pulse width, pulse energy and power were measured as a function of input voltage and nitrogen pressure. The optimum condition for

The second part of this chapter contains details of laser design and fabrication. The laser constitutes mainly of plasma tube, spark gap, high voltage capacitors, high voltage power supply, trigger circuit and gas flow system. To have high electrical-to-optical conversion efficiency and high pulse-to-pulse stability, it is necessary that the discharge be uniform in the plasma tube. For this, a cylindrical cathode and plane anode configuration is selected as suggested by some of the earlier workers. A free-running type spark gap and a triggered spark gap with trigger circuits are developed for the laser. These have low inductance and high current capability. A 20 KV switched mode power supply is used. Double side copper-clad fibre-glass epoxy laminates are used as high voltage capacitors. The gas supply into the plasma tube is designed so as to obtain uniform gas flow throughout the discharge region.

The second chapter gives the results of a thorough investigation carried out to optimise the laser characteristics. It includes a study on the variation of laser power with applied voltage and pressure in the plasma tube. This has been done for the laser with both free-running type spark gap and triggered spark gap. It is found that the laser with free-running type spark gap has higher efficiency. But stability in the repetition rate as well as in the pulse intensity is better for the triggered spark gap. The above studies could establish that the latter is more suitable for pumping a dye laser.

In the third chapter the design and fabrication details of a tunable dye oscillator pumped by the above nitrogen laser is given. The chapter begins with a discussion on different oscillator configurations with grating and prism as dispersing elements. The relative simplicity of grazing incidence grating configuration is established. The bandwidth of the tuned output for various angles of the grating are tabulated. Other performance details like pulsewidth, peak power, divergence, tuning range and efficiency are also given in detail.

A dye laser oscillator in narrow band operation is generally inefficient and has high amplified spontaneous emission (ASE) as background noise. If the oscillator is followed by an amplifier, high output power in narrow bandwidth can be generated with high conversion efficiency. Chapter four describes how the overall performance of a dye laser is improved by adding a travelling wave amplifier to the oscillator described in the previous chapter. An analysis on travelling wave amplification is given at the beginning. Methods of decreasing ASE are described subsequently. Results on the measurements of optimum pump power distribution and optical delay between the oscillator and amplifier stages are given. The concentration range over which efficient extraction of laser energy takes place, is different for oscillator and amplifier. A study has been carried out to find out the same. Finally results are given to establish that, by using the amplifier, the power in the tuned wavelength is appreciably increased while divergence and ASE are decreased.

Dye laser efficiency and tuning range depend also upon the solvent and the concentration of the dye solution taken. The tuning range is directly related to the ASE bandwidth. It is, therefore, important to know the ASE bandwidth at different concentrations in different solvents. Chapter five contains such a study for the case of Rhodamine 6G in some frequently used solvents. It is observed that even within a small concentration range the bandwidth varied appreciably.

Chapter six presents the results of some studies on lasing characteristics of mixed dye systems. The peak laser wavelength as a function of the concentration of the donor and acceptor is measured. It is established that by using dye the maximum power was determined from these measurements. Also, the efficiency of the nitrogen laser was calculated. This nitrogen laser in the optimum condition was then used to pump the dye laser.

An electronic scan system was fabricated and was coupled to a grazing incidence dye laser. This was used to scan the wavelength of the dye laser output continuously and also in steps of 1, 2.5 and 5nm. It was possible to scan the wavelength of the dye laser from 430 nm to 630 nm with this set up. The circuit details and the working principle of the scan drive system are given in the fourth chapter of the thesis.

Querry et al. reported a split-pulse laser method to measure absolute attenuation coefficient of water. This method overcomes all the drawbacks of earlier methods. It was found to be very sensitive even to measure the low attenuation coefficients of distilled water. Hence, this method was adopted in the present investigations and attenuation coefficients as low as $10^{-4}$ $cm^{-1}$ were measured with this set up. A detailed description of the experimental technique and the calculation of the attenuation coefficient are included in the fifth chapter of the thesis.

In order to determine the effect of dissolved constituents of sea water on the optical attenuation, a systematic study of optical attenuation was undertaken starting with distilled water. The study of optical attenuation in distilled water is required as a basic reference before attempting the solutions. It may also be pointed out that the existing results on distilled water reported by various authors show major discrepancies. Therefore, a detailed study was conducted in doubly distilled water. Seven distinct peaks were observed. The peaks are explained in terms of overtones and combinations of the O-H vibrational modes. The anharmonicity parameter for the O-H vibration is calculated. The absolute values of the attenuation coefficient and its relation with wavelength are determined accurately and are presented in the sixth chapter. Also, a comparison is given between the results of the present work with those of the earlier workers.

The salts of sea water can be broadly classified into major constituents, minor constituents and trace elements. The major constituents mainly determine the salinity of the sea water because the concentrations of the salts of the major constituents are about three orders above that of the minor constituents and about six orders above that of the trace elements. Therefore, a detailed study of the effect of the individual salts of the major constituents (NaCl, $MgCl_2$ and $Na_2SO_4$) was undertaken.

Attenuation coefficients were measured in solutions of NaCl, $MgCl_2 6H_2O$ and $Na_2SO_4$ for various concentrations. The concentrations were selected on the basis of the amount of individual salts found in natural sea water. Attenuation coefficients were measured in four concentrations of NaCl, three concentrations of $MgCl_2 6H_2O$ and two concentrations of $Na_2SO_4$. Absolute values and the relation of attenuation coefficient with wavelength are given. A comparison of the results of the above salts are also given.

"Artificial" sea water was prepared with a salinity of 35% with major constituents of sea water alone and the attenuation coefficients were measured. The result shows the influence of individual salts. In order to study the influence of the salts of the minor constituents of sea water, another artificial sea water was prepared with major and minor constituents with a salinity 35%. Attenuation coefficients were measured for this sample and the result indicates the influence of the minor salts. Absolute values of the attenuation coefficients and their relations with wavelength for all the solutions are given in chapter six. The results obtained from these experiments are also discussed. All the measurements were carried out in the wavelength range 430 nm to 630 nm in steps of 2.5 nm. Because of the narrow interval between the measurements as compared to the total wavelength range it was possible to obtain smooth curves for all the solutions studied here.

General conclusions are drawn based on the study and are presented in the last chapter. For all the solutions, there is a sharp increase in the value of attenuation coefficient above 580 nm. Attenuation coefficient is found to be influenced much by $Na_2SO_4$ and $MgCl_2$. But NaCl does not have much influence on the attenuation coefficient. Influence of the minor constituent of sea water is very small compared to that of $Na_2SO_4$ and $MgCl_2$. For all the solutions, the band at which the attenuation coefficient is minimum falls in the region 450-500 nm. General conclusions and suggestions for further studies on the optical attenuation in sea water are also given as a result of the present studies.

## S.P.40. MADHUSOODANAN, K.N. – Photoacoustic Investigation of the Optical and Thermal Properties of Selected Amorphous Chalcogenide Semiconductors – 1989 – Dr. Jacob Philip.

Amorphous semiconductors form an important class of materials from the point of view of fundamental condensed matter research as well as technological applications. It has become a frontier area of research during the past two decades. Since these materials, like other glassy solids, possess only short-range order, the theory developed for crystalline materials cannot be applied to them. Eventhough several models and theoretical formulations have appeared in literature, extensive studies are still going on because a clear theoretical understanding of the physics of non-periodic or random systems is yet to be evolved. Several problems in this area still remain unsolved.

Amorphous semiconductors find several applications in electronic and optoelectronic devices such as solar cells, memory and switching elements, imaging technology etc. But the full potential of these materials for technological applications is yet to be completely explored for which a thorough understanding of their properties is essential. The preparation, characterisation and systematic study of the properties of amorphous semiconductors are very important in the light of the above facts.

Our aim has been to investigate systematically the optical and thermal properties of selected bulk chalcogenide semiconducting glasses. We have concentrated our studies on $A^{IV}B^{VI}$ and $A^{V}B^{VI}$ type binary chalcogenides where, $A^{IV}$ is a group IV semiconductor atom such as Ge or Si, $A^{V}$ is a group V atom such as As and $B^{VI}$ is a chalcogen atom such as Se or Te. We have used a relatively new technique viz., the photoacoustic (PA) technique for these investigations. The PA technique, which is based on the detection of acoustic signals generated when a sample absorbs modulated light beam and relaxes non-radiatively has proved to be very effective in the study of optical and thermal properties of solids, liquids and gases. Photoacoustic spectroscopy (PAS) is especially powerful in the study of highly absorbing and scattering materials where other conventional spectroscopic techniques often fail. The technique is very convenient to do spectroscopy of amorphous semiconductors as these materials are highly light absorbing and are often in the powder form. We have carried out a detailed and systematic investigation of the optical absorption and thermal transport properties and their composition and temperature dependences in a few selected $A^{IV}B^{VI}$ and $A^{V}B^{VI}$ chalcogenide glasses in the glass-forming range using the PA technique.

One of the important advantages of compound amorphous semiconductors is that they can be prepared over a very wide composition range. Since the physical properties do change with composition, this provides composition dependent tunability of these properties which is helpful for the selection of desired materials for specific applications. Therefore the study of the composition dependent variation of the physical properties such as optical energy gap and thermal diffusivity are very important for these materials. A number of studies, using different techniques, for determining composition dependence of various other physical properties, appeared in literature have provided a great deal of information about the short–range order, the glass-forming tendency of the solid, network stiffening etc. A large percentage of such investigations have been on materials prepared in the thin film form. But not much work has been done on the composition dependence of the energy gap and thermal diffusivity in bulk amorphous semiconductors. Temperature dependence of such parameters have not been reported at all on these materials. The samples have been prepared by the well established melt-quenching technique for bulk samples. A detailed account of the results of the work done by us as mentioned above is presented in the thesis which we are going to submit. In the following paragraphs we give a chapterwise description of the thesis in brief.

The first chapter of the thesis, written in two parts, is an introductory one giving general introduction to the physics of amorphous semiconductors and to the principle and technique of photoacoustic spectroscopy. The first part viz., part-A is devoted to a review of the status of amorphous semi-conductor research and part-B gives a review of photoacoustics and photoacoustic spectroscopy. Here emphasis is given to topics which are relevant to the work presented in the thesis. Preparation, classification and characterisation methods of different types of amorphous semiconductors are briefly reviewed. Some of the interesting properties and theoretical models of these materials are also outlined and discussed. The principle of the photoacoustic effect, its use as an analytical tool and its various applications are presented with special reference to the absorption spectroscopy of semiconducting samples in part B. The necessary theory of the PA effect is also briefly outlined in this first chapter.

Chapter 2 is devoted to the description of instrumentation and the experimental set-up used in the work. The PA spectrometer used in our experiments consists of a 1 KW Xenon lamp, a source monochromator, light beam chopper, lock-in amplifier etc. The PA cell which forms the most important part of the PA spectrometer has been fabricated in our laboratory. A sensitive electret microphone is used to detect the generated acoustic signal. Two cells have been fabricated, one is a small volume non-reasonant cell for room temperature measurements and the other is a Helmholtz resonator type cell for measurements at higher temperatures with which measurements can be made upto 500K. The PA cells are so designed that different backing materials can be used for the sample. Organisation of the PA spectrometer, design and calibration of the cells etc., are described in detail in this chapter.

Chapter 3 deals with the optical absorption studies on $A^{IV}_{x}B^{VI}_{1-x}$ binary glassy systems using photoacoustic technique. The systems studied include several compositions in the glass-forming region of $Ge_xTe_{1-x}$ $(0.15 < x < 0.28)$, $Si_xTe_{1-x}$ $(0.10 < x < 0.28)$ and $Ge_xSe_{1-x}$ $(0.10 < x \leq m\ 0.38)$ glasses. The PA spectra, which is essentially the variation of PA amplitude with incident wavelength, give the optical absorption characteristics of the samples. These are reported for the above three systems. The variation of the optical energy gap, determined from the PA spectra, with the composition parameter x is presented for all the three systems. It is found that the energy gap increases with increase in the concentration of group IV element with a marked change in slope at $x = 0.20$. In Ge-Se system, in which measurements have been taken for compositions with x upto 0.38, the optical energy gap is found to have a peak value around the $x = 0.33$ composition which is the stoichiometric composition for these systems. The observed behaviour is explained on the basis of chemical bonding and the change in short range order in the network.

Another system of glass whose optical absorption characteristics we have investigated is the $Se_{1-x}$ system with $0.10 \leq x \leq 0.50$. This system belongs to the $\beta^{vi}$ family of chalcogenide glasses. In chapter 4 the PA spectra of these samples are presented and the results are discussed. The variation of the optical energy gap as a function of the composition parameter x shows a minimum at $x = 0.40$ at which stoichiometric $As_2Se_3$ glass is formed. An explanation for this behaviour is again given on the basis of the chemical bonding between atoms in the network. Short-range order in the material changes with change in composition and this is explained on the basis of existing models.

The PA technique has proved to be a very effective method for determining the thermal transport properties of solid samples. We have determined the thermal diffusivity of $Ge_xTe_{1-x}$ $Si_xTe_{1-x}$ and $Ge_xSe_{1-x}$ glasses belonging to the $A^{IV}B^{VI}$ system as well as $As_xSe_{1-x}$ and $As_xTe_{1-x}$ glasses belonging to the $A^{V}B^{VI}$ system by studying the variation of the PA amplitude with chopping frequency using samples of appropriate thickness. The thermal diffusivity is $Ge_xTe_{1-x}$ $Si_xTe_{1-x}$ and $Ge_xSe_{1-x}$ glasses belonging to the $A^{IV}B^{VI}$ system as well as $As_xSe_{1-x}$ and $As_xTe_{1-x}$ glasses belonging to the $A^{V}B^{VI}$ system by studying the variation of the PA amplitude with chopping frequency using samples of appropriate thickness. The thermal diffusivity is determined from the relation $f_c l^2 = \alpha$ where l is the sample thickness and $f_c$ is the characteristic frequency above which the sample is thermally thick. In chapter 5 the results of these measurements on the systems mentioned above are reported. The variation of the thermal diffusivity as a function of the composition parameter x gives evidence for the existence of certain critical compositions in these systems. From the results obtained on the $A^{VI}B^{VI}$ systems it has been possible to establish the existence of stable structures with minimum disorder at $x = 0.20$ composition. At this composition the thermal diffusivity and consequently thermal conductivity is found to have a threshold maximum value in all the systems studied. Also in $Ge_xSe_{1-x}$ system the thermal diffusivity shows a maximum value again at $x = 0.33$ where the stoichiometric $GeSe_2$ glass is formed. Also in $A^{V}B^{VI}$ systems, in the composition range studied, ,the thermal diffusivity has got a threshold maximum value at $x = 0.40$ which corresponds to the stoichiometric composition for these systems.

In chapter 6 a theoretical explanation for the existence of critical ,compositions in chalcogenide glasses as evidenced by the results presented in the previous chapter is given on the basis of constraints theory and the idea of rigidity percolation in random networks. According to Phillips' theory of non-equilibrium glass formation, the glass-forming composition is optimized mechanically by equating the number of force-field constrains whcih are intact at the glass transition temperature to the number of atomic degrees of freedom. In the glass-forming region the system contains both floppy and rigid regions. The thereshould behaviour in thermal conduction exhibited by $A^{IV}B^{VI}$ and $A^{V}B^{VI}$ glasses is attributed to the mechanical stiffning of the glass network at the critical compostions as a result of the thershoold percolation of rigidity. Considering the central bond-stretching and rotationally invariant bond-bending forces for a binary alloy system $A_xB_{1-x}$ based on the ideas of rigidity percolation and effective medium theory, the critical average coordination number works out to be 2.4 for a 3-dimensional rendom network. This agrees well with our experimental observations which give evidence for the existence of critical composition at X = 0.4 for $A^{V}_{x}B^{VI}_{1-x}$ glasses. The value of the average coordination number turns out to be exactly 2.4 at these critical compositons for both the systems.

In chapter 7 we present the results of the PA studies on $A^{IV}_{x}B^{VI}_{1-x}$ and $A^{V}_{x}B^{VI}_{1-x}$ glasses at high temperatures using the high temperature PA cell with which measurements can be done upto≈ 500K. We have measured the variation of the PA signal amplitude and phase with temperature and their chopping frequency and wavelength dependence at various fixed temperatures. From these the temperature dependence of the optical absorption, optical energy gap and thermal diffusivity have been determined. The results obtained above, at and below the glass transition temperature are presented in detail for one representative from the $A^{IV}_{x}B^{VI}_{1-x}$ family viz., $Ge_xSE_{1-x}$ system and for one representative from the $A^{V}_{x}B^{VI}_{1-x}$ family viz., $As_xSe_{1-x}$ system. The absorption is found to depend on temperature and a decrease in the optical energy gap is observed with increase in temperature. A significant decrease in thermal diffusivity is found to occur at the glass transition temperature in all the samples studied. The results obtained form these high temperature studies are presented and discussed in detail in this chapter.

Chapter 8 is the concluding chapter. It incorporates the overall conclusion of the work presented in the earlier chapter. The use of the PA technique as a powerful tool for the study of some of the important physical properties of chalcogenide glasses is emphasised. The importance and relevance of the study of composition dependent variation of such properties is highlighed on the basis of the contents of the thesis. Further scope of work in this direcion to investigate the optical and thermal properties of other amorphous semiconductors using PA technique is discussed.

Most of the results presented in the thesis have already been published in the form of about 10 papers in International journals recently.

## S.P.41. – MOOSAD, K.P.B. – Studies on some Nonlinea Optical Phenomena - Optical Phase Conjugation and Continuous wave second harmonic Generation – 1989

## – Dr. V.P.N. Nampoori.

Nonlinear optice has emerged as a new area of physics following the development of various types of lasers. A number of advancements, both theoretical and experimental, have been made in the past two decades, by scientists all over the world. However, only few scientists have attempted to study the experimental aspects of nonlinear optical phenomena in Indian laboratories. This thesis is the report of an attempt made in this direction.

The thesis contains the details of the several investigations which the author has carried out in the past few years. On optical phase conjugation (OPC) and continuous wave (CW) second harmonic generation (SHG). OPC is a new branch of nonlinear optics, developed only in the past decade. The author has done a few experiments on low power OPC in dye molecules held in solid matrices, by making use of a Degenerate Four Wave Mixing (DFWM) scheme. These samples have been characterised by studies on their absorption-spectra, fluorescence spectra, triplet lifetimes and saturation intensities. Phase conjugation efficiencies with respect to the various parameters have been investigated. DFWM schme was also employed in achieving phase conjugation of a broadband laser (Nd: Glass) using a dye solution as the nonlinear medium.

SHG is one of the most important of the several second order nonlinear optical effects, in view of its apllications. Although SHG is common with pulsed lasers, it is not so in the case of CW lasers. The author has developed an indigenous system for SHG in a ring dye laser, making use of this Lithium Iodate crystals. The tunable coherent ultraviolet beam thus obtained was successfully applied for spectroscopic investigations.

The thesis has been set in six chapters and two appendices. The FIRST CHAPTER is a general introduction to nonlinear optics. Various nonlinear optical effects due to the second and third order nonlinear susceptbilities are discussed. The derivation of an expression for nonlinear optical susceptibility is outlined.

CHAPTER TWO is an account of DFWM and OPC. The throries of DFWM in transparent and absorbing media are examined.

CHAPTER THREE contains the details of the experimental investigations made on a few low power saturable absorbers as candidates for low power OPC. The specific cases studied are the dyes eosin, erythrosin B and Rose Bengal, taken in thin films of gelatin, polyvinyl alcohol (PVA) and boric acid glass. The properties of these systems in relation to their suitability for OPCare experimentallyinvestigated, which include the absorption spectra, flourescence spectra, triplet-life times, and saturation intensities. The absorption spectra indicated that the boric acid glass samples do not absorb strongly at 514.5 nm wavelength while in the other two films it does, indicating that the boric acid glass samples cannot be used for working at the wavelength 514.5 nm of the argon ion laser. The time evolution of the fluorescence emission is shown to be a quick check for saturation in absorption in these films. However, the actual determination of the saturation intensities were done by plotting the transmission vs. incident intensity curves. It was found that the transmission increased indefinitely, suggesting that irreversible damage is occuring to the dye molecules. Saturation intensities were therefore measured by repeatedly plotting the transmission vs. incident intensity curves and making sure in each case that no irreversible changes had occured. These meaurements were supported by measurements of the triplet lifetimes also. A few studies of the fluorescence of these dyes in the above matrices, which, though interesting, are not directly related to the OPC studies, are described in the Appendix I.

SECTION I OF THE CHAPTER FOUR is the details of the studies of OPC in the above samples. Phase conjugation efficiencies versus the input powers, absorption lengths and wavelengths are studied and compared with the theoretical models discussed in the previous chapters. Of three dyes used, erythrosin B showed the highest efficiency, both in gelatin and PVA films. Efficiencies were always greater in PVA films than in gelatin films. The best efficiency achieved was about $10^{-5}$, for erythrosin B in PVA film. Efficiency varied with the input power - peaked around the saturation intensity and then decreased. This was not only due the inherent behaviour of the interaction but also due to the laser-induced damage of the dye molecules. This damage is found to occur very fast. Efficiency varies with the absorption legnth also. It was found that there exists on optimum for this. Another aspect affecting the efficiency is the "wash-out" effects due to vibration pick-ups. This also was found to be very severe.

In the SECTION II OF THE CHAPTER FOUR, OPC experiments using a Nd: Glass laser are described. An absorbing dye Kodak 14015, dissolved in 1,2, dichloroethane is used as the nonlinear medium, in a simple DFWM scheme. here are only few reports of OPC via DFWM of broadband radiations. Actually, there are no reports at all, where OPC of Nd:Glass laser has been achieved by a DFWM technique. The present investigations showed that it is possible to achieve this.

CHAPTER FIVE presents the details of the attempts made on developing an indigenous system for CW SHG, using Lithium Iodate Crystals. Two types of crystals were used - "perpendicular-cut" and "Brewster-cut". The best output power obtained was about 1.85 milliwatts. Tunability of a few nanometers was possible. This beam was used in an experiment for detection of OH radicals in air contained in a multi-pass cell. The details of this experiment are also reported briefly in this chapter.

CHAPTER SIX is a summary of the main features of the work.

APPENDIX I presents the details of the studies on fluorescence spectra of the samples used for low power OPC. APPENDIX II is a pedagogical aspect of OPC. It is suggested that this method of obtaining an OPC beam is ideal for introducing OPC as laboratory topics in post-graduate courses. Details are discussed, alongwith suitable experimental evidences.

Most of the results reported in the thesis have been published elsewhere or submitted for publication.

# Faculty of Technology

## T.1. VASANT DEO PRABHA–R.M.S. Measurements–1981–Dr. C.S. Sridhar

The root-mean-square (RMS) value is widely used in statistical measurements, signal analysis and power measurements. It is a conventional measure of signal amplitude. In case of sinusoidal signals the rms value is indirectly measured by sensing the average of the peak value. In modern systems the signals are highly complex. The required precision of measurement on such complex signals demands true rms measurement.

The concept of an idealized rms detector is introduced, for the first time, in order to assess the generalized performance characteristics. An rms detector possesses two basic characteristics, frequency and amplitude responses. For the sake of generalization these characteristics are assumed to have rectangular form, like the frequency characteristic of the ideal band pass filter. The amplitude errors for commonly occurring complex signals are calculated for a specified dynamic range ($V_L$ to $V_H$) of the rms detector. A computer program is written and run to determine the frequency error in rms measurement on a variable duty cycle pulse-train. The two errors are compared and it is revealed that in case of the measurement on medium and low frequency complex signals, it is the amplitude error that plays an important role.

The thesis presents a solution to the problem of rms measurement on high crest-factor signals. The highlights of the thesis are as follows:

(1) A systematic analysis of errors in rms measurement is presented for the first time. (2) The importance of amplitude error (waveform error) is revealed. (3) The relationship between the squarer error and the rms measurement error is investigated. (4) It is revealed that the constant squarer error results in hyperbolic rms measurement error characteristic. (5) The squarer error is so shaped that the resulting rms measurement error is independent of the signal level. Thus a flat error characteristic is achieved. (6) A waveform-error-free rms detector is developed which can be used for measurement on signals of any complexity-high CF signals, sinusoidal signals, gaussian or nongaussian random signals. (7) The successful development of a square-rooting A/D converter permits hybrid rms measurement consisting of analog rms computation and digital display. (8) The effects of unconventional feed back in 'Implicit RMS Computation' are investigated and the limitations of this popular rms computing technique are revealed. (9) A new criterion is proposed for digital averager. It provides lot of flexibility in selecting the sampling frequency and the number of samples. (10) The original work presented in this thesis has to its credit three publications.

## T.2. P.R. SASEENDRAN PILLAI–Studies on Underwater Propagation–1982–Dr. C.S. Sridhar

One of the most peculiar limitations that stands in the way of achieving maximum transmission range in sonar systems is caused by the 'mutual interaction effect' among the radiating elements of a closely packed projector array. Unless this effect is compensated for in the design of the array, it will cause severe complex effects at higher drive levels. An attempt has been made, in this work, for designing and developing sonar projector arrays taking into account the interaction effect.

In order to minimise the mutual interaction effect in an array system, a loosely packed array (LPA) format has been proposed. This LPA format has the unique advantage that closely packed planar projector arrays, the elements of which are arranged at half-a-wavelength apart can be converted into the proposed format by selectively switching only those elements that produce the desired beam characteristics. The selective switching of the elements of the closely packed array is achieved by a microprocessor based switching system. The switching system and the closely packed arrays have been suitably implemented to achieve lobe switching, shading by average amplitude in time (SAAT) and higher array gain, with suitable program controls. A programmable array has been developed and implemented for achieving lobe switching and SAAT operation. Finally, one of the applications of the LPA format for the generation of low frequency sound beams through nonlinear interactions has also been suggested.

## T.3. G.M. AJIT–Advanced Microcomputer Based Numerical Control System–1984–Dr. C.S. Sridhar

A Computer based numerical control system replaces hard wired logic circuitry with a general purpose Software Oriented processor, flexibility being the most significant benefit. Primary function of any NCS is to sequence the axis of a m/c tool through the steps of a part program and it is grouped into three as (i) Data input (ii) Axis Control (iii) Sequence Control.

In this thesis, modularity in hardware is achieved by adopting a popular micro computer bus standard namely multibus IEEE 796 and the hardware consists of only five multibus compatible boards and standard peripherals. All modules connected to the multibus standard behaves in a master slave relationship. The multibus data transfer operates on a handshaking principle so that no one module depends on another's internal timing. The maximum rate for the bus being 5 MHz.

Interpolation, the most important computational task performed by a NC (contouring) system is carried out with the help of an IC chip KM 3701. KM 3702 is the Servo Control IC closed loop system is used for axis control to get better performance. The position feed back is provided by an optical encoder and a resolver coupled to the end of the axis motor. The encoder based control system consists of an up-down counter, a digital to anlog converter, power amplifier and a DC Servo motor. The encoder interface circuit has to sense the direction of movement, generate the countup and countdown pulses to be fed to the KM 3702 which is achieved with a quad latch and a PROM chip using the circuitry proposed by Ciancaghini. The hardware requirements in the micro computer board to be used for the CNC system is met with an 8 bit microprocessor - Z80 A. Optically isolated input and output board are used to meet I/O system requirements.

The Software is designed as a portable modular package enabling it to have a value and lifetime greater than any particular hardware environment. The special features of the package include a powerful machine tool operating system MTOS with file management, provision for simultaneous operation as a CNC System and as a voice input tape preparation system, angle programming, Safe zone programming etc. and all other advanced features found in modern CNC System for lathes. THE CNC System designed here is a two-axis contouring control for lathes i.e. x and z axis. The system for developing the Software consists of Z-80 based $\mu$c, power supply, dual mini floppy disk drives, CRT terminal, printer along with floppy disk based Z-80 assembler and text editor program. The control panels to be scanned consists of the front panel of the CNC system and a remote control panel mounted on the machine.

The System Software Scans the % "$\mu$" feed rate switch the real time interrupts service routine execution and up dates the O/P feed rate if required. The rotary switch O/-P are interconnected so as to supply a 4-bit binary number corresponding to percent of override selection as input to the system. The main function of the software module is to decode the part program and execute it. The programming format is prepared in accordance with the recognised ISO, DIN and EIA standards. In order to reduce the delay between the execution of the blocks of part program to a minimum, the entire part program is compiled and stored in separate buffers. The compilation is done during every active cycle, start from the present block to be executed to the last.

A Voice recognition module (VRM) is also tried for data entry. The Software is developed using assembly language and the complete CNC system is tested by interfacing it to the NHCNC lathe located in HMT Ltd. Kalamassery.

## T.4. E.V. THOMAS–Development of Energy saving forms of rubber–1985–Dr. D. Joseph Francis

This thesis describes several methods of saving energy in natural rubber processing. In the conventional processing the latex obtained from the rubber tree is coagulated and then the coagulum is dried. Then the rubber is masticated and then mixed with compounding ingredients. The compound is then shaped and vulcanized. The following are the energy saving methods extensively discussed in the thesis.

1. **Oil extended natural rubber:** Oil extension of natural rubber is done by emulsifying mineral oil and mixing with rubber latex. The mixture is then coagulated to precipitate the oil extended natural rubber. This process is found to save much energy in the compounding step.
2. **Incorporation of peptisers:** In this study dispersion of peptisers are added to latex and then coagulated and processed. This procedure is found to cut the energy required for mastication to a large extent.
3. **Use of particular clones of rubber tree:** The rubber from different clones is found to have different viscosities. So selection of rubber from selected clones could drastically reduce the energy in the mastication step.
4. **Latex stage compounding:** Latex stage compounding is found to be a very useful technique in saving energy compared to conventional rubber processing.

## T.5. K.E. GEORGE–Studies on polymer blends with special reference to NBR/PVC & CR/PVC blends–1987–Dr. D. Joseph Francis

This thesis describes the developments of novel polyvinyl chloride (PVC) blends and modification of the existing PVC blends for wider applications.

The first phase of the study is development of novel compounding ingredients for use in PVC blends. A novel stabilizer system based on MgO/ZnO combination is developed for PVC and this is found to be useful in blends of PVC with elastomers. A new curing agent, tribasic lead sulphate is developed for polychloroprene (CR) rubber. This is also advantaeously made use of in PVC/CR blends.

As the second phase of the study, several methods of improving the performance characteristics of NBR/PVC blends are described. It involves making use of the novel compounding ingredients, employing optimum blending parameters for a given blend composition, using natural rubber, styrene-butadiene rubber, polybutadiene rubber and polysulphide rubber to modify NBR/PVC blends for economic and/or technical advantages.

As the third phase of the study, several method of preparing CR/PVC blends are described in the thesis. The CR rich blends could replace CR with advantages such as higher strength higher hardness and modulus, better heat and ageing resistance and lower cost. In PVC rich blends, CR acts as a plasticizer without affecting the oil resistance, chemical resistance, weather resistance or nonflammability of PVC.

## T.6. G. DEVARAJAN-Non-linear filtering: applications to digital, signal processing, median filtering, structures, Analysis & applications-1988- Dr. C.S. Sridhar -Dr. V.K. Aatre

Median filtering is a simple digital non-linear signal smoothing operation in which median of the samples in a sliding window replaces the sample at the middle of the window. The resulting filtered sequence tends to follow polynomial trends in the original sample sequence. Median filter preserves signal edges while filtering out impulses. Due to this property, median filtering is finding applications in many areas of image and speech processing. Though median filtering is simple to realise digitally, its properties are not easily analysed with standard analysis techniques.

In this thesis, a new method of characterising Median filters through matrix operator is introduced. From this a new parameter 'column sum' which gives several features of the signal is extracted. The column sum distribution leads to a tree structure from which root paths and state diagrams are evaluated. Theory is developed to get the exact number of passes to reach a root sequence for any given sample sequence.

In addition, two new filters, Fast Convergence Median Filter Interpolation Median Filter are introduced. These two filters are applied in image processing and the results are presented. Theoretical analysis of Median filter on deterministic signals is carried out in frequency domain.

The median filter realisation in terms of minimum hardware for on-line processing is described. Added to this, a VLSI design structure with unit delay is presented. Median filtering is applied in the area of constant false alarm processor, image processing and speech processing and the results are discussed.

In conclusion, the median matrix and column sum enable one to extract several interesting properties. FCMF and IMF are very useful in on-line image processing and feature extraction. The ranked operation filter design and its application to underwater target detection is a very useful algorithm.

## T.7 C.K. ANANDAN-Compact broad band microstrip antennas using parasitic elements-1988-Dr. K.G. Nair

Recently use of microstrip antenna is becoming increasingly popular since they have been found to be light weight, simple and inexpensive to fabricate. The inherent disadvantage of microstrip antennas is their narrow impedance bandwidth. A large number of works have appeared on the problem of increasing the bandwidth of microstrip antennas. Additional resonators gap coupled to the driven patch antenna have been used for improving the impedance characteristics. However, these configurations increase the overall size of the antenna to a large extent together with the distortion of the radiation pattern. A compact antenna configuration which gives enhanced bandwidth and less distorted radiation pattern has been developed and is analyzed in detail. The system contains a number of parasitic elements which are gap-coupled to a driven patch. The methodology adopted is as follows:

The method adopted is the parasitic technique. In order to keep the overall size of the system a minimum, the driven patch and parasitics are made thin. Since the resonant frequency depends on the patch width, here the driven patch and the parasitics are made of unequal widths to achieve multiple resonances. The various parameters involved such as parasitic width, position of the parasite, number of parasities, the feed point location etc., are studied in detail in this thesis.

The effect of parasitic elements gap coupled to a driven patch antenna is studied and is found that the input impedance drastically changes due to the presence of parasites. This shows that the parasitic elements can be utilized to modify the impedance characteristics. When coupling gap is increased, it is observed that the two resonant frequencies come closer and a proper choice of gap-width gives desired upper and lower resonant frequencies.

The study of the change in impedance characteristics of the parasitic loaded antenna with feed location shows that as in the case of a single patch antenna, the impedance is also increased as the feed is moved towards the radiating edge.

In the designed broadband antenna, a number of parasites are gap-coupled to the non-radiating edge. Coupling due to each parasite is adjusted by varying the gap width experimentally. For the present system the bandwidth is increased to eight times that of an individual patch antenna. Extension of this in the case of a number of parasites of arbitrary width and coupling gap can be taken up for further study in this field.

## T.8 RANI JOSEPH-Curing studies of elastomer blend with special reference to NR/SBR & NR/BR blends-1988-Dr. D. Joseph Francis

This thesis describes the ways of achieving the covulcanised state of two-component elastomer blends where the blends are cured in such a way that the crosslink densities in the two phases are optimum.

First part of the thesis describes ways of relating the curing behaviour of an elastomer blend to the compatibility between the constituents. This is a very convenient and simple way of judging the compatibility compared to the conventional methods available.

In the second part of the study blends of natural rubber with styrene-butadiene rubber singled out for detailed study due to its commercial significance. Effect of various curing systems on the mechanical behaviour and network structure of the blend is described. As the third part of the study, a detailed discussion on the behaviour of blends of natural rubber with polybutadiene rubber is given.

## T. 9 RAVINDRAN, T.–Studies on polyurethane elastomers based on liquid natural rubber–1989–Dr. D. Joseph Francis

Segmented polyurethanes are a class of thermoplastic elastomers of great commercial importance. These materials derive most of their useful properties from the incompatibility of the hard and soft segments and subsequent phase separation into separate domains. The soft segment is usually a polyether or polyester of molecular weight between 1000 and 5000 possessing a glass transition temperature (Tg) well below ambient temperature. Hard segments are typically formed by the extension of an aromatic diisocyanate with a low molecular weight diol or diamine and have a Tg or melting transition (Tm) above the used temperature. The hard segments provide physical crosslinking, act as reinforcing fillers and are responsible for the performance of these materials at high temperatures. The existence of phase separation into separate micro domains has been well documented for block copolymers and segmented polyurethanes. Hence the physical and mechanical properties are interpreted on the basis of a two phase model. Most polyurethane studies are complicated by one or more of the following effects. (1) Specific interactions between phases via hydrogen bonding (2) cystallinity in either phase and (3) the presence of chemical crosslinking. All the three effects may influence the nature and extent of phase segregation. These complications can be avoided by using a hydrocarbon back bone having nearly exact difunctionality. W.J. Macknight et.al studied a system of polyurethane elastomers where the back bone was hydroxyl terminated polybutadiene (HTPB) Taking these as a guideline we prepared polyurethanes with HTNR soft segments. Polyurethanes upto 70% hard segment content were synthesised.

Block copolymers based on HTPB and poly (ethylene oxide) (PEO) are reported in literature. The use of preformed poly(ethylene oxide) and carboxyl terminated polybutadiene for the preparation of block copolymers are also reported. Correlation between their structure and composition with tensile properties and water absorption capability have been conducted. These materials are excellent hydrogel forming substances. Hydrogels upto 82% water content were obtained. Based on the above references we studied the possibility of synthesising block copolymers from HTNR and preformed poly(ethylene oxide) with varying molecular weights. Block copolymers upto 64% PEO content were synthesised.

The thesis has been divided into five chapters.

In the first chapter an overview of the important research work in the area of Natural Rubber degradation and on the preparation of liquid Natural Rubber with reactive end groups is presented. The review highlights the important achievements in the field of NR degradation. This chapter also includes an introduction to the synthesis of polyurethanes based on hydroxyl terminated polybutadiene (HTPB), which in turn forms the guideline for the synthesis of HTNR based polyurethanes and block copolymers.

The second chapter deals with experimental procedure for the depolymerization of natural rubber. The rubber used was Natural crumb rubber (ISNR-5, number average molecular weight ($M_n$): 8,20,000; Intrinsic viscocity in benzene at 30 C 4.45 dl/g; Wallace plasticity ($P_o$) 59.0) supplied by the Rubber Research Institute of India, Kottayam. 30 wt. % Hydrogen peroxide (supplied by E.Merck, India) was used. Toluene, methanol and tetrahydrofuran were of reagent grade, distilled before use.

Both masticated and raw natural rubber were used for the preparation of HTNR. The effect of ultraviolet light and sun light were studied on the photochemical depolymerization of NR. Detailed investigations conducted on the product obtained by analysing the IR, NMR,$^{13}$ C-NMR spectra and the gel permeation chromatography results. Based on the above results a mechanism for the formation of HTNR and side products are also discussed.

Chapter three deals with the preparation and evaluation of mechanical and thermal properties of poly urethane elastomers based on HTNR. Materials used are HTNR ($M_n$-3000) prepared in our lab, butane 1,4 diol (Fluka, Switzerland), dibutyl tin dilaurate (Fluka, Switzerland) and toluene disocyanate (Fluka, 80/20 mixture of 2,4 and 2,6 isomers).

The polyurethanes are synthesised by one stage, two stage (bulk) and two stage (solution) polymerizations. Their tensile properties are evaluated, using a Zwick-1445 universal testing machine, Thermogravimetry was conducted on a Dupont 1090 Thermo gravimetric Analyser at a heating rate of 20 C $min^{-1}$. Differential scanning calorimetry was performed on a Dupont 9000 thermal analyser system. A heating rate of $10^{o}C$ $min^{-1}$ and a sensitivity 2 or 5 $m.cal.5^{-1}$ were used. Optical was microscopy done on a 'Leitz' Orthoplan microscope.

A series of HTNR containing polyurethanes have been synthesised by 3 different synthetic routes. The soft segment Tg value was found to be very close to that of free HTNR and independent of hard segment content indicating complete or very nearly complete phase segregation. Since the hard segments of TDI/BDO are amorphous, the driving force for phase segragation must arise from the large degree of incompatibility between the polar hard segment and non polar soft segment. Further in these samples there is also no opportunity for hydrogen bonding between hard and soft segments to enhance compatibility. With increasing hard segment content, the property vary from soft to rigid elastomers and rubber toughened plastics. This variation in properties is caused by changes in the sample morphology which depends on the relative fractions of hard and soft segments.

The contents of chapter four are the syntheses of block copolymers based on HTNR and preformed PEO with different molecular weights. Evaluation of mechanical and thermal properties are also included.

Block copolymerization was carried out by the coupling of equimolar amounts of these polymers, with toluene diisocyanate (TDI). Tensile properties and water absorption capability of these polymers were determined. Hydrogels upto 80% water content were obtained. Polymerizations were conducted using one stage, two stage (bulk) and two stage (solution) techniques. Two stage (solution) gave best results which can be attributed to homogeneous reaction conditions provided by the solution polymerization technique, so that perfect $(AB)_m$ type poly. structure can be obtained where A refers to the soft rubbery segment and B to the hard PEO segment. Optical micrographs showed a two phase morphology which again arises from the reactant incompatibility. DSC studies show a single glass transition for the soft segment and the value of which is almost a constant for the series of block copolymers and is only 6°C above the glass transition temperature of free HTNR. It is already reported that an increase in Tg of 4°C of the soft segment in the block polymer above the corresponding nomopolymer Tg, corresponds to complete phase segregation. Our results indicate that phase segregation in these samples is complete or very nearly so.

Fifth chapter gives an overall conclusion of the results and discussion of chapters 2, 3 and 4, a brief summery of all the chapters along with some suggested applications for the synthesised materials.

# Faculty of Law

### L.1. SEBASTIAN, V.D.–Legislative conflicts in India–1976–Dr. A.T. Markose

This is a study of the legislative conflicts arising out of the Union, State and Concurrent legislative jurisdictions established by the Constitution of India. It is confined to the conflicts on account of the vertical division of powers as the subject-wise distribution of powers is sometimes called. This study has been based in the main on the Constitutional provisions and Supreme Court decisions. Occasionally, High Courts' decisions have also been referred to. The selection of the topics included in the study has been so made, as to cover all questions of significance.

Regarding conflicts between exclusive fields, it is submitted that even in instances of transfer of State field to the Union by Parliamentary declaration or by resolution of State legislature (article 252) or by the exercise by the Union of treaty-making power (article 253), the State law existing in the field will "wither away", and there is no need to invoke the principle of repugnancy for resolving conflicts in this area.

Registration that may become colourable because of the covert attempts to exercise judicial power, to overcome the limits imposed by the fundamental rights or by the distribution of powers, and to exercise under the guise of ancillary powers what properly lies outside the main grant of power, have all been considered.

Legislative conflicts relating to industry and mining is examined with a view to striking a balance between enlargement of Union powers and, curtailment of states' power. The view that, on a declaration by Parliament the States cannot exercise their acquisition and requisitioning powers with regard to the property of a controlled industry has been shown to be erroneous. The interpretation of the term 'industry' has been shown to be too narrow. In the field of education the conflict regarding the power to prescribe the medium of instruction has been examined in the light of leading decisions. The need for the Union instrumentalities charged with the co-ordination and determination of standards of higher education to spell out more fully the policy that is required to be uniform to leave no no-man's land in this area has been brought out.

The effects of the ad-hoc allocation of residuary powers under the Government of India Act 1935, and its grant as an exclusive power to the Union under the Constitution, have been examined in detail. How the residuary power has added a new dimension to the Union power, has been examined.

Another idea canvassed is that article 254(1) applies only to conflicts in the concurrent field.

Conflicts between exclusive and concurrent fields have been shown to raise a question of power and not of conflict between the laws made under the power. Conflicts are solved on the principle of harmonious construction, of pith and substance, of incidental encroachment and of hierarchical arrangement of the jurisdictions. A few illustrative conflicts in this area have been considered.

The main conclusions in the body of the thesis have been summarised and brought together in the last chapter.

The following are the main contributions made to the subject in this study.

1. On the doctrinal side, the confusion regarding the principles to be applied for the resolution of conflicts between powers and between laws made under power has been removed. It has been shown that for the resolution of all conflicts between exclusive fields (including cases where a part of the State exclusive field is transferred to the Union), or between the exclusive and the concurrent fields, the doctrines of pith and substance, of incidental encroachment, and of the hierarchical arrangement of the three legislative jurisdictions are sufficient.
2. The need for the judiciary to canvass policy questions more openly in applying the principles of pith and substance, and of repugnancy, has been pointed out.
3. In the field of colourable legislation a new and comprehensive analysis has been presented. A suggestion has been made for reforming the criteria adopted for the tax-fee distinction.
4. The criticism of the accepted principles of the doctrine of immunity of instrumentalities has been shown to be based on an untenable view of federalism.
5. Regarding industry and mining, the undue curtailment of the State power on parliamentary declaration on the one hand, and the need for developing a proper interpretation of the term 'industry' itself have been established.
6. The need for an activist role by the Union instrumentalities in giving contents to "co-ordination and determination of standards in institutions of higher education....." has been shown.
7. The view that not merely the sale that occasions export but the one immediately preceding that shoule also be exempt from State sales tax in the interests of export trade has been canvassed.
8. The new role of residuary powers in the interpretation of the entries in the lists has been pointed out.

## L.2. PARAMESWARAN, K.–The Power of Taxation Under the Indian Constitution–1977–Dr. A.T. Markose

The power of taxation is an incident or attribute of sovereignty. The taxing power is essentially a legislative power. No government can adequately discharge its maniford duties in the contemporary world without it. Its constitutional significance requires legitimate popular sanction for its collection. These are some of the reasons why the term 'tax' has always required rigid definition at various levels. The definition and the related explanations of the term in the introductory chapter attempt this task.

At the constitutional level the power of taxation requires differentiation from two other attributes of sovereignty, namely, the police power and the power of eminent domain; the power of taxation can conceivably be used to achieve the objects of the other two powers. Further, one meets one of the inherent limitations on the power of taxation, namely, that it should not be used for any private purpose. The introductory chapter also explains in some detail the functional aspect of the power of taxation especially as a device of regulation in modern society apart from collection of revenue.

At the legislative level taxation is distinguished from various other impositions of a like nature such as prices, fines and penalties imposed by criminal courts and other authorities. The power of taxation being an all comprehensive and the most pervading of all the powers of the state, an examination of the limitations imposed at the constitutional level is essential. The details of this area are studied in the subsequent chapters. First chapter in Part I is devoted to a study of the scheme of the distribution of the taxing power between the Central and State legislatures under the Indian Constitution. The liberal construction of these legislative entries provides for all incidental and ancillary powers. Chapter II deals with the special types of exercise of taxing powers such as retrospective taxation and taxation by self governing authorities. The different types of retrospective taxation, such as from the simplest form of imposing a tax from a past date to that of imposing a tax from an anterior date when the legislature itself was not in existence, are noted. Chapter III deals with the problem of delegation in favour of executive government and that in favour of local authorities. The basis of the difference is that in the case of delegation of taxing power to local authorities, the principle of safeguard against abuse of power by the delegate is similar to that of Parliament or state legislatures and hence decisions dealing with such delegation form a separate category.

Part II reviews the various types of taxes and other impositions. The distinction between tax and fee is taken up in the fourth chapter of this part. The desirability of excluding certain types of rent for use and occupation of government property and "fee" for enjoyment of certain privileges (eg. the right to deal in liquor, which the state alone has power) from the category of fees is pointed out. It is suggested in this context that the present state of law relating to admissible items of expenditure from the collections of fee is not at all satisfactory even though it allows the courts to be the arbiter to decide whether the imposition is a fee or not.

Chapter V deals with the essential characteristics of tax on property, lands and buildings in contrast to wealth tax. Also discussed here are gift tax and taxes on inheritance. Chapter VI deals with the tax on sale or purchase of goods and excise duty. There are some generally accepted differences between the two taxes. Chapter VII deals with tax on income and tax on trade or profession. Chapter VIII deals with the two trade taxes, namely, customs duty and octroi duty. The problem whether the octroi tax is a restriction on the freedom of inter-state commerce is examined here. Chapter IX deals with tax on motor vehicles, tax on passengers and goods and toll mining whether toll is a restriction on the freedom of interstate commerce. Chapter X deals with all other taxes and imposts of a like nature. The different taxes dealt with in this chapter are taxes on advertisement, on luxuries, on entertainment, on betting and gambling, on electricity, on boats, on animals, capitation tax and the stamp duty aspect it is a fee. The levy of royalty is not in the nature of a tax but a premium. The cess and surcharge are not independent taxes but only additions of particular taxes.

Part III consisting of two chapters is devoted to the subject of restrictions imposed by the fundamental rights on the power of taxation. The delicate function of judicial review to decide the validity of fiscal legislation is the highlight in this part. Chapter XI deals with the impact of Article 14 on the taxing power of the state. Here there is a critical evaluation of the efficacy of the oft-repeated tests of reasonable classification to decide the validity of fiscal statutes. The courts are generally handicapped because of their lack of expertise in fiscal matters. The two common defects usually found in fiscal statutes, are under-inclusive and over-inclusive classification. Both result in incidental hardships to the individual. But both also easily pass the gauntlet of judicial review. The power to grant exemption, which is a power to subclassify is dealt with separately. Here decisions of courts illustrate the utter futility of the test of reasonable classification.

Chapter XII deals with limitations imposed by what are popularly known as the 'seven freedoms' on the power of taxation. The task of balancing the taxing power with the rights of trade and property is performed through the test of reasonableness of the restriction. The difficulty of this task accounts for the reluctance of the courts to extend the operation of Article 19 to fiscal statutes. The concept of expropriatory taxation stands on a different footing. Here the legislative fiat traverses the permitted field of regulation to enter the forbidden territory of confiscation. The courts readily interfere in such cases.

Part IV is devoted to freedom of inter-state trade and commerce and taxation on sale or purchase in the course of inter-state and international commerce. Chapter XIII deals with freedom of inter-state commerce and the related provisions of the Constitution of India. The comparative law in U.S.A. and Australia is referred to. Chapter XIV is devoted to the restrictions on the power of the states to impose tax on sale or purchase which takes place in the course of inter-state or extra-national trade. The problem of multiple taxation by different states on the same commodity is discussed. The five stages through which this problem got solved is of abiding interest to a student of federal taxation. The restrictions imposed by Parliament of India on the power of States to impose sales tax on "declared goods" is then discussed. The last part of this chapter studies the restrictions imposed by Article 286(1) (b) on the power of States to impose tax on sales and purchases taking place in the course of import or export of goods. The legislative induction of State Trading Corporation into all export and import agreements has further complicated the situation as illustrated by the Mohammed Serajuddin case.

The general nature of the theory of inter-governmental and its historical background in India under the Government of India Act, 1935, the position under the Constitution of India under Article 285, the immunity of the Union Government, immunity in relation to railway property and the immunity of State Governments under Article 289 are all subjects of study in Part V. The question whether such immunity from taxation is available to statutory corporations, created by the Parliament and State legislatures, the narrow meaning given to the term "property" appearing in Article 289 by the Supreme Court of India and the other constitutional provisions dealing with immunity from taxation are dealt with.

Part VI is on the Centre-State financial relations. The first chapter deals with the problem of taxation in federal finance. The Constitution of India has set up a federation with independent responsibilities and functions assigned to the Union and State Governments. In principle, the Constitution has to safeguard the financial viability of the Centre as well as that of the States. However, a bare perusal of the Seventh Schedule of the Constitution would convince one that the elastic sources of revenue have been assigned to the Central Government. The Constitution provides for the systems of tax sharing and grants-in-aid for the protection of the States. The dynamics of both these are analysised. It is suggested that the present system of distribution of different taxes on different bases has to be abandoned. The Finance Commission has to distribute all such revenues on the basis of one principle among the States. Such a principle is pointed out.

Chapter XVII is devoted to the study of the working of grants-in-aid to the States. The reports of the Commonwealth Grants Commission are studied for a comparative understanding of the principles for fixing such grants-in-aid. The working of the Indian Finance Commission in this area of grants-in-aid is also taken up in some detail. It is pointed out that the reports of the Finance Commission do not give the method by which the exact amount to be given to a State is arrived at. In this respect, the report of the Sixth Indian Finance Commission (1973) is very helpful: The Commission has calculated the amounts of grants-in-aid on the basis of the national average expenditure on social services like education, public health, etc. Even in such a case, the factor of tax severity in a State is a matter to be given consideration. The inclusion of one of the members of the Planning Commission in the Finance Commission has solved much of the controversy over the duplication of the functions of grants-in-aid by both the Finance Commission and Planning Commission.

## L.3. CHANDRASEKHARAN, N.S–Dismissal in Industrial Employment–1983–Dr. P. Leelakrishnan

The thesis is a study in Labour Law. The area of study is the law relating to dismissal of workman in industry.

Dismissal is a serious matter. It carries a stigma. With this stigma attached to him, a dismissed employee may find it difficult to obtain alternative employment, especially in a land where the problem of unemployment is acute. The need for law, with built-in safeguards, taking care of arbitrary dismissal cannot be overemphasized. The study from this perspective, examines to what extent the Industrial Disputes Act 1947 protects the interest of workman in industry, what restrictions on dismissal are placed by the Act and how far the remedies are adequate.

A host of issues other than dismissal may also arise between workmen and employer. They may give rise to industrial disputes. Raising of an industrial dispute may worsen the relations between workmen and employer. Bitter feelings are aroused. Antagonism develops. This may be the inarticulate major premise on which the employer be tempted to resort to the extreme step of dismissing some workmen against whom he has prejudice. With a view to preventing this eventuality the Industrial Disputes Act imposes certain significant restrictions on dismissal. The scope of these restrictions is examined in detail.

Service may be terminated in the form of simple discharge although in effect the termination is dismissal for a misconduct. The availability of protection to such cases is examined. The study assesses critically the jurisdiction of the authority in granting or refusing permission for and approval of dismissal. When the employer does not comply with the requirements of permission or approval the Industrial Disputes Act provides the workman with a remedy. He can file a complaint before the Labour Court or Tribunal. Does the jurisdiction of these adjudicatory authorities go to the extent of examining not only the question of legality but also merits of dismissal? The scope of this remedy is critically examined.

Before a workman is dismissed a domestic enquiry may be held against him. The law in this area is examined critically to see whether it ensures that the workman gets an adequate opportunity for defence. The process of domestic enquiry is analysed and infirmities brought to light.

Does the workman have an effective remedy within the statutory frame work against unjustified dismissal? This issue is intertwined with the problems of reference to adjudication and arbitration provided in the Industrial Disputes Act. The scope and extent of the jurisdiction of the adjudicatory authorities are analysed and the areas which require further improvements identified.

The restrictions of permission and approval in pendency operate as a safeguard only for the workmen concerned in the dispute. The protection should be made available to all workmen who stand against the management in a pending dispute. Application for permission filed during pendency should not lapse when the pendency ceases. The authority should continue to have jurisdiction in disposing such application even after pendency.

The limited jurisdiction of the authority in the case of permission or approval has resulted in duplication of proceedings. A dismissal effected with permission or approval of a tribunal may become again the subject matter of an industrial dispute. It may be referred for adjudication. To avoid this duplication, the tribunal should be given wider jurisdiction. It should have power to examine the merits even in a case of permission or approval. It should also have the power, at this stage, to examine the question whether or not the punishment is excessive.

The employer should be compelled to strictly observe the statutory requirements. When a workman is dismissed in violation of the law the authority should order reinstatement.

Pitted against competent managerial personnel, the workman, often illiterate and ignorant, is seldom equipoised. He should have the right to be represented by competent persons in the domestic enquiry. The right to representation should form part of the rules in domestic enquiries. A mechanism has to be evolved in which domestic enquiries are held not by managerial personnel but by an independent agency or atleast by a person agreeable to both parties.

## L.4. SADASIVAN NAIR, G–Mental Abnormality and Criminal Responsibility–1984–Dr. P. Leelakrishnan

The study is on the relationship between psychology and criminal law. The introductory part examines the basis of criminal responsibility dealing with guilty mind and purposes of punishment showing that how guilt is absent in, the cases of mentally ill persons. Defence of insanity in common law under the M'Naghten Rules and other alternative tests of criminal responsibility like irresistible impulse test, doctrine of diminished responsibility, New-Hamphire rule, Durham rule, American Model Penal Code test and the German rule are critically evaluated in Part II.

Judicial exposition of the concept of insanity in Indian law is the theme of Part III. The theories of insanity under section 84 of the Indian Penal Code, the required nature of unsoundness of mind and degree of insanity for exemption from responsibility and the distinction between medical and legal insanity are discussed. Various types of mental illnesses like delusions, epilepsy and automatism, hebiphrenia, homicidal mania and irresistible impulse, insomnia, puerperal insanity, pyromania, schisophrenia, somnabulism and insanity due to intoxication are examined as to how far they are sufficient grounds for exemption from responsibility from the point of view of judicial opinion.

Burden of proof of insanity is highlighted in Part IV. The different views taken by the High Courts like the heavy burden rule, ,the liberal view and the more rational and balanced view and the authoritative rule laid down by the Supreme Court are discussed. On a critical analysis of the case law, lack of a definite standard of proof in insanity cases is experienced though the burden of proof is liberalised by the Supreme Court. A new approach is suggested making insanity defence a matter of evidence whereby benefit of exemption is to be given to the accused where insanity is apparent on evidence on the basis of preponderence of probability. This will minimise the hardship created out of lack of reform in substantive law of insanity in India. Objective criteria of proof like atrocious nature of the crime, previous and subsequent conduct of the accused, previous and subsequent insanity, role of witnesses, expert and nonexpert, and the greater role of psychiatric evidence in England are all explained.

Developments in psychiatry and the relationship between law and psychiatry are the themes of Part V. Mental abnormality, mental illness and crime are examined from the view of free will theory and basic concepts of psychiatry. Psychological analysis and classification of criminal behaviour and psycho-analytic approach to crime is surveyed. Developments in England and United States in the matter of substantive law, procedure, evidence and treatment of mentally abnormal offenders are also surveyed. Concept of 'guilty but mentally ill", bifurcated trials and sanity hearings in the mental asylums in U.S.A. and the concept of 'not guilty on evidence of insanity' as suggested by the Butler Committee Report in England are of matters of great interest in this context. The inadequacies of Indian law in this background and the role played by the Indian Law Commission in law reform in substantive and procedural aspects is also analysed in this part. It is gratifying to note that long pending Mental Health Bill on the lines of the English legislation has been enacted into law with some modifications in the form of Mental Health Act, 1987. The problem of mentally abnormal offenders has to be rightly in the light of total mental health problem and not simply as a problem of criminal responsibility.

In the concluding part a spot light on the inadequacies of law and practice in this area is taken from the perspectives of lawyers, authorities and inmates of prison and lunatic asylums by way of an empirical survey. Reforms in the field of substantive, procedural, evidentiary aspects of law and in the treatment of mentally abnormal offenders are suggested. The most important among the suggestions are: (1) Reform of substantive law of criminal responsibility under section 84 of the Penal Code by introducing either the concept of diminished responsibility available in British Homicide Act 1957 or the substantial impairment of the cognitive faculties test of the U.S. Model Penal Code.

(2) Examination by a psychiatric expert of every suspected mentally ill offender immediately after the commission of a serious offence of violence.

(3) Psychiatric evidence should receive more recognition in criminal trials.

(4) Mentally abnormal offenders are to be subjected to psycho-therapeutic treatment wherever possible.

(5) The Indian Lunacy Act is to be amended (The suggestion has already been carried out by passing of the Mental Health Act, 1987.)

(6) Magistrates and convicting courts and the visitorial committes should periodically visit the prison and lunatics asylums more effectively to secure

the rights of the mentally abnormal offenders and in securing their acquital at the appropriate time.

(7) Sanity hearing should be allowed in the lunatic asylums in determining their recovery in which advocates and medical men should help the lunatics.

(8) Mental health tribunals, similar to those under the British law should be established.

## L.5. VARKEY, A.–Administrative Controls of Companies in India–1984–Dr. V.D. Sebastian

Increasing State interference in the economic life of its citizens is a common phenomenon in the modern world. Company, a standard form of all business activities, is not exempted from such interference. The nature, function and impact of such State interference in the working and progress of the corporate sector is the subject matter of this study.

Administrative control over corporation existed in some form or other even in the early days. With the emergence of a large number of trading companies, the State interference increased to reduce the abuses of corporate form of business. The sphere of corporate control went on increasing to meet the changing needs of the society. The nature and extent of administrative controls over companies in India also faced gradual changes to meet the social needs and to satisfy the changing social ideology.

At present, the controls of companies in India, may be classified into (1) shareholder controls, (2) Judicial controls, and (3) administrative controls. A brief but critical study of these controls is made in the work. This study reveals that the shareholder controls and the judicial controls have many limitations.

One of the important objective behind administrative control over companies is the protection of public interest. The Government is acting as the guardian and the protector of public interest. But, the State is a party having substantial interest in the matter in which it acts as an arbitrator or as a judge. This makes the study of this problem very important in the present day. The difficulty in ascertaining what 'public interest' is, also creates much confusion. This aspect is given due importance in the study. The possibility for a reconcillation between the two contesting interests, the public interest and the individual interest, is considered here.

At the stage of formation and expansion of companies, a large number of administrative controls are provided in the law. The controls are generally exercised through registration and licensing provisions. The simplification of these procedures without liberalising the controls is considered necessary.

Administrative controls for the protection of investors and creditors have been emphasized in the study. The need and sufficiency of disclosure provisions at the time of issue of shares and debentures is considered in the light of decided cases.

Maintenance of share capital is of much concern for all those who are interested in the company. Therefore, restrictions are placed on reduction of share capital. Payment of commission, brokerage, etc. on the issue of shares are thus restricted to a great extent. While forfeiture of shares and surrender of shares are allowed to some extent, there is total prohibition on purchase of own shares by companies. In the light of the recent developments in England, there appears to be no harm in allowing companies to purchase own shares under certain circumstances. For this purpose strict conditions and limitations are to be prescribed by the Legislature.

Another important power of the Central Government in relation to the shares of a company is the power to hear appeares from shareholders when registration of transfer of shares is refused by the directors. Most of the Companies by its articles give wide discretionary powers to the directors to refuse registration of transfer of shares. Unlike administrative discretion, the control over the exercise of discretion by the directors is much limited.

Prevention of economic concentration is another objective sought to be achieved though the administrative controls. Mergers, amalgamations and takeovers are controlled for this purpose. The study reveals that what is controlled in India is not the concentration of economic power. Only when the economic concentration turns out to be prejudicial to public interest, governmental interference is made to check the abuse.

Many of the administrative control provisions under the Companies Act 1956 are designed to regulate the conduct of the management of companies and to ensure better protection to the shareholders, investors and the creditors. Provisions of the Companies Act ensuring "federalism" in company management is critically studied. The result is not encouraging. Even though the shareholders are "sovereign" in theory, their actual role in management is not significant. Search for a better system by which a pleasant reconciliation of the different competing interests in the management of companies is made. Defining and delimiting the powers and duties of the three most important partners of a company, the management, the shareholders and the workers, is considered essential for this purpose.

The Government enjoys considerable powers to regulate the appointment and removal of directors and other managerial personnel of a company. The study reveals that even though these powers are administrative in nature, the Courts have prescribed standards to determine whether an action taken under these provisions is arbitrary or not. Abuse of these powers may cause havoc to the economic life of the country. Fortunately, the judiciary has proved to be a vigilent guard against such abuses.

Administrative action against a company may take different forms. Inspection of company documents, investigation, prevention of oppression and mismanagement, winding up, etc. are some of such powers. Inspection and investigation are considered as drastic steps which may shake the credit of a company. But if the provision for inspection and investigation is properly used, it can prevent a number of abuses by company management and prevent many company liquidations. This along with the power of the Central Government to take action for the prevention of oppression and mismanagement could be developed as an alternative remedy to winding up. The nature and extent of administrative powers exercised over the conduct of winding up is also subjected to a fair discussion.

Finding a proper forum for settlement of disputes arising out of the administration of company laws is one of the difficult problems at present. The present position is analysed to focus these difficulties and to suggest alternate methods.

To sum up, the process of administrative controls over companies at all stages of operation of a company is discussed in this study. Based on such discussion, some concrete suggestions are made to improve the situation, wherever found

## L.6. KESAVANKUTTY, V–Cinematographic licencing–1985– Dr. P. Leelakrishnan

A commonly adopted system of control over exhibition of film in many countries is the method of licensing based on the suitability of film. India is not an exception. Regulation on film is many sided. This study concentrates on censorship of film for public exhibition only. It brings to light the defects and shortcomings in the existing system and suggests means to rectify them. The history of film censorship, different types of censorship, the criteria for censorship and the legal framework are also areas of enquiry in this study.

Some countries like the United States, England, Japan and West Germany adopt a system of self-regulation. Censorship of film is carried on by an authority constituted by the film industry itself. Even in spite of its intrinsic weakness in enforcement and sanction, the system is adopted in those countries mainly for avoiding compulsory censorship by the State. In some other countries there is no censorship prior to the commencement of exhibition of films, but the film maker, exhibitor, or distributor can be punished if such exhibition constitutes a violation of criminal law. Another model is that the censorial powers may be conferred on civil court so that the court, on application, can determine whether the film is objectionable or not. Films are also subject to invisible and indirect censorship. The impact of all such censorship on films is discussed.

In India, film censorship originated with Cinematograph Act 1918 empowering the Provincial Governments to establish censorial authorities. In 1949, an amendment provided for a Central Board of Film Censors. In 1952, a new legislation gave the Central Government enormous powers, making the Board to function as a department of the Central Government. The Government had control over the Board with the mechanism of issuing 'directions' to the censors and laying down censorship rules. The legislation did not provide any objective criteria for censoring films. The 1959 amendment, aimed at curing this defect, only incorporated the grounds contained in Article 19(2) of the Constitution. Even after expert studies and a significant decision by the Supreme Court, pointing out the inadequacy of the existing system, and governmental attempts to bring reforms by way of fresh directions, appointment of appellate authority and framing of new rules, the system still warrants radical change. The thesis explores them.

The history of official censorship of films in the United States is one of long legal battles. The initial judicial attitude was not to grant the protection of First Amendment to movies. By 1960, the judiciary accepted in theory the validity of prior censorship of movies but demanded proper standards for censorship. Later, the judiciary stressed the need for strict procedural safeguards. Fearing compulsory state censorship, film industry set up its own censorial system and a production Code. Although this self-regulatory system slacked legal sanction, the industry secured the co-operation and support of the Church. In 1966 the industry willy nilly adopted the grading system. Under the grading system its duty was limited to classifying films for different age group. Lack of sanction against isolation and resultant difficulty in implementation are the draw-backs of the system.

In England a loose system of self-regulation is in force. The power of local authorities for censorship was the creature of judicial interpretation. Realising the difficulties of a city censorship system, the industry, in 1916, set up the British Board of Film censors and successfully pursuaded the local authorities and the Home Office to accept the decisions of the Board. The obscene Publications Act, 1959 originally exempted cinemas from its purview. The judiciary took the view that prosecution could be initiated against a film maker or distributor under the common law offences of outraging public decency and corrupting public morals even if the film is passed by the Board. This created a new threat to the film industry. In order to save the industry from this the Criminal Law Act, 1977 brought films within the purview of the Obscene Publications Act.

Recent trend all over the world is to give more emphasis on protection of children than on censoring of films for adults. In England, originally a two tier system of classification prevailed. One was based on the suitability of the film for children and the other on the general suitability for public exhibition. In 1921 the London County Council adopted a rule which banned from the second category films, all children under sixteen years of age unless accompanied by a bonafide adult guardian. Soon this became a standard form of licencing condition. In 1951, another category namely films meant for adults only was evolved. Later, 1970, a fourth category namely films suited for Children above 14 was introduced. The second category films was made open to all but with a warning that the film may not be suitable for children below 14 years. Thus a four tier system of classification exists in England.

Eventhough, as seen in the United States legal sanction is wanting, classification system enables the censorial authority to classify films more reasonably and logically to suit the requirements of pre-teenagers and teenagers. However, India demonstrably lags behind the categorisation of films as adopted in England and in the United States. For a long time there were only two categories, one for unrestricted public exhibition and the other for public exhibition restricted to adults, ie., for persons above 18 years. Only after the commencement of the 1981 amendment, an intermediary category was recognised - an advisory category with the object of advising parents that the film may not be suitable for children upto twelve years. Even though any classification based on age is bound to be arbitrary, a classification between preteenagers and teenagers appears to be reasonable and logical and therefore it will be a welcome step, if provision is also made for introducing a category for teenagers. The 1981 amendment further introduced an 'S' category in which the film is passed for public exhibition restricted to the members of any profession or any class of persons having regard to the nature, content and theme of the film. A true significance of this category is yet to be determined.

The principles for censorship of film in India are contained in Section 5B of the Act, a verbatim reproduction of the grounds specified in articles 19(2) of the Constitution. Eventhough the constitutional validity of this section was upheld, the Supreme Court did not explain the real import of various terms therein. The competency of the Central Board of Film Certification to censor films is examined. The desirability of an Appellate Authority and the suitability of the Government as a reviewing or revising authority are also examined. The power vested with the Government to issue directions to the Board does little contribution in guiding censorship. A discussion on the "Directions" is made in the thesis.

A vital question is the "bar of jurisdiction of courts" over the decision made by the Board. The statute specifically excludes jurisdiction of a criminal court to deal with any matter decided by the Board. But there is no specific provision ousting either expressly or by necessary implication, the jurisdiction of civil court.

The essential for ouster of jurisdiction under the general law, ie., the availability of an effective remedy within the statute with a built in judicial procedure is absent. Without upsetting the balance of decisions made by expert bodies, the study explores how grievances of those affected by a decision could be redressed by providing mechanisms of appeal and review.

The Cinematograph Act 1952 provides for administrative sanctions and judicial sanctions. In the field of judicial sanctions there are problems. Provision for the same punishment for different category of offences without taking into consideration the gravity and seriousness of the offences is critically examined. The rigour of the penalty is to be reduced. The inadequacy of the enforcement machinery and lack of co-ordination between the Board and the State Police force are hurdles in the smooth working of the censorship process.

On the basis of legal analysis and an emperical study interviewing film producers, directors, critics, viewers, theatre owners etc. an attempt has been made to ascertain the suitable machinery for film censorship in India. However, an ideal system of censorship must strike a balance between the freedom of expression of the film maker and the larger interests of society, and shall be capable of commanding respect from the industry and the public. The present highly Government controlled system does not find favour either with the industry or with the general public. Establishment of an independent Board of Film Certification with regional agencies consisting of fulltime members having sufficient knowledge and expertise in cinema is the dessideratum. The secrecy surrounding the Board may be done away with. The Board may be required to justify its decision to the public for whom censorship is carried on. The mechanism of 'directions' will have to be reformed.

## L.7. RAJAN K.E. VARGHESE–'Wage Policy in Indian Industries' –1986–Dr. N.S. Chandrasekharan

The thesis is a study on a very important area of labour law. The term 'wages' has been defined differently in labour statutes to suit different purposes. There is need for a uniform definition atleast for purposes of laws with a common objective.

The components of wages, like basic wage, dearness allowance and other allowances and the rationale behind such classification is probed in the study. The relation between wages, cost of living and standard of living is brought out. An empirical study on the standard of living of certain factory workers is made. Problems relating to dearness allowance, such as the extent of neutralisation, the justification for such neutralisation, the formula for fixation of dearness allowance and the need for merger of dearness allowance with pay are critically examined.

The role of an appropriate wage policy in a Welfare State is probed. A historical background of the labour policy in India, indicating the transformation of the country into a welfare state committed to social justice, is made out.

Attempts at formulation of wage policy in Indian industries, as reflected in the Five Year Plans, are examined and the conclusion is reached that the question of wage policy was not given due importance in the Five Year Plans.

The provisions of the Payment of Wages Act 1936 are discussed with reference to relevant case law, the adequacy of the provisions is looked into, implementation aspects are examined and appropriate changes suggested.

The machinery and methods for fixation of wages under the Minimum Wages Act 1948 are examined, the defects in the law and the lapses in implementation identified and remedial measures pointed out. Various measures to raise the standard of living of Indian worker are suggested. Factors like capacity to pay and avoidance of economic imbalance in a region are appropriate bases for a proper wage policy. The diverge problems which arise in that connection are probed and solutions sought.

The system of collective bargaining as a wage settlement mechanism is examined, tracing the development of the system in India, assessing the merits and demerits and probing into the strategies of this method in wage fixation.

The study on wage fixation through conciliation and voluntary arbitration reveals that the success of both the systems depends substantially on the prevalence of a spirit co-operation between the parties.

The working of the machinery of wage boards is examined, the defects in the system are identified and measures to overcome the defects suggested.

Examining the adjudicating process the study brings out the extent to which this method is suited for solving disputes on wages. The study canvasses for a centrally co-ordinated wage policy in Indian industries.

## L.8. SUKUMARI ANTHERJANAM, D.–Women and Criminality –1988–Dr. R. Prasannan.

Women criminality has not been subjected to any serious study in India although it has assumed new dimensions in recent times. Statistics show that the rate of increase in the arrest of women year after year was more than the increase in the arrest of men. The number of female arrests during 1971 for the offences under the Indian Penal Code was 16,303 and it reached 45,900 in 1980 which shows an increase of 181.54%. But in the case of males there is an increase of 72.42% only during the same period.

In view of the increasing importance of the subject an in-depth socio-legal study was undertaken taking 250 samples from among the female prisoners in the Central Prisons and in the District Jail (Calicut) in Kerala. They were interviewed and the details of the criminal records collected, collated and analysed. Information was also collected from judicial officers through questionnairs and interview.

The analysis of the data collected in the process of this study signified several factors including the causes of criminality among women. They included broken homes, financial insecurity, illness, lack of education, poor housing, bad neighbourhood, marital problems and sexual imbalances.

Our present criminal justice system is found inadeqate to effectively check the rising trend in women criminality.

The present system of bail which gives much emphasis on the financial soundness of the sureties also at times works out injustice to the women offenders who usually belong to the lower strata of the society.

The enforcement authorities are not complying with many of the provisions of the Criminal Procedure Code with regard to arrest, custody and search. Police stations quite often tend to be torture centres although there are rigid statutory provisions for the security of women offenders.

The study also reveals that the sentence awared by the courts are not effective. Many of the functionaries punish offenders for the sake of punishment alone. It seems that many of sentencers have not yet started appreciating the fact that crime could be due to reasons beyond one's control. The lack of proper training of judicial officers in the matter of sentencing and the lack of a well defined sentencing policy with reference to women offenders make it almost impossible for judicial officers to award the sentence appropriate to women offenders. An overwhelming majority of the offenders have not been represented before the courts by lawyers. This has further aggravated their disabilities. The women offenders are also not usually granted probation. The Judicial officers are indeed inclined to show leniency in awarding sentences to the women offenders.

Regarding the prison life of women offenders, it was noticed that the undertrials and convicts are often kept in one block where they have every opportunity to mingle and communicate with each other. The general condition of prisons was found to be unhygienic. The prisoners are also not given opportunities for acquiring knowledge on morals, hygiene and good manners. Nor are they trained in any skilled and useful work.

Many of them are not allowed to keep their kids with them in prison. The authorities are not giving proper care and attention to the children who are permitted to live with their mothers in prison. It is also a fact that the jail staff do not give assistance for submission of appeal petitions.

Lack of after-care services has created apprehensions in the minds of the prisoners. Once convicted they become unacceptable to the community to which they originally belonged. This 'state of affairs' has quite often led to increase of recidivism.

The study looks at the problem of women' criminality from diverse angels, analyses the causative factors of crime, evaluates the process of criminal justice system and identifies defects in the law and practice with a view to formulating appropriate measures for the future development of the law on proper lines.

## L.9. MUHAMED KUTTY, K.B.–Export Import and Inter-State Sales - A Study in Tax Law–1989–Dr. N.S. Chandrasekharan

The study deals with the nature of sales tax, its coverage, the constitutional prohibitions, the restrictions on levy of sales tax in the case of export, import and inter-state sales and brings out the vital problems and suggests solutions.

The constitutional scheme of prohibition of tax on sale and purchase in the course of export and import is analysed with a historical perspective. The early development of law from the Travancore cases is analysed and critically evaluated.

The study reveals how the subsequent judicial decisions had at times pushed to the extreme the distinction drawn in the Travancore cases between a sale 'in the course of' export and one 'for the purpose of' export.

The development of the law relating to taxation of sale and purchase in the course of export and import after the sixth amendment to the Constitution and the enactment of the Central Salestax Act are examined and the fluctuating trends analysed and the validity of the principles evaluated. The effect of canalisation of export and import on the incidence of sales taxation, the development of the law and its impact on the export, import and domestic trade are subjected to close study.

Some legislative changes were brought about extending the scope of exemption to penultimate sale culminating in export. This was with a view to mitigating the hardship to the export trade. The discussion brings to light legislative loopholes. Further changes needed in the legislation are suggested with cogent reasons.

The tax liability on goods imported against actual users licence is studied. The impact of the present law on industrial development is analysed. A case is made out for extending the exemption to the first sale after import.

The problems connected with inter-State sale are examined from the very early stage of Explanation Sales. How far the evil of multiple taxation was set at naught by the introduction of Article 286 in the Constitution is examined.

An inquiry into the enactment of the constitutional provision is made and the judicial interpretation of the concept of inter-State sale discussed. The tests of sales occasioning inter-State movement and of sale effected by transfer of documents of title during the movement of goods from one State to another are examined elaborately along with the problems involved in effecting inter-State transactions through agents and branch offices. The study examines how the constitutional and the legislative provisions came to be interpreted at the hands of the judiciary and makes a reasonable plea for legislative changes including further extension of control in respect of more items consumer goods and raw materials.

The study examines the constitutional framework in its historical setting for translating into practice the freedom of trade and commerce. An empirical investigation made possible a realistic assessment of the impact of the existing law. The results of the study are analysed and suggestions made for progressive development of the law.

## L.10. NAGABHOOSHANAM P.– Social Justice and Weaker Sections: Role of Judiciary –1989–Dr. P. Leelakrishnan.

The thesis examines the role of judiciary in rendering justice to two distinct groups of weaker sections mentioned in the Constitution of India, viz., (i) Backward classes and (ii) Women.

Attempting to find out the meaning and extent of the concept of social justice chapter I looks into the views of statesman and philosophers and tries to show that social justice is linked with the right to equality.

In Chapter II the Constituent Assembly Debates and the provisions of the Constitution are examined to determine the true scope of the constitutional ideal of social justice. Judicial decisions relating to right to property are analysed to show that the courts had a slow start which prompted Parliament to act and to declare specifically in the preamble that ours is a 'Socialist' republic, opening the way for the new orientation in the juristic techniques of the Supreme Court.

The recent pronouncements of the Supreme Court which created a wave of judicial activism are discussed in Chapter III. Many a hurdle blocks the way of the socially handicapped millions in reaching the doors of the courts and getting their grievances vindicated. The evolving access jurisprudence indicates that the judiciary keeps pace with the changing mores of the day informed by the values of social justice enshringed in the Constitution.

'Backward Classes' is not defined in the Constitution. The Chapter IV examines the criteria on which these classes are identified. The view in Champakam Dorairajan that caste is not a criterion led to the first amendment introducing class (4) to Article 15. This is examined. Reports of various Commissions appointed by the State Governments and Central Government are elaborately discussed. Holding that backwardness in social hierarchy as the basis some of those studies suggested a blended approach, ie., a means-cum-caste test.

What is the judicial approach throughout these years towards the criteria of backwardness? Chapter V represents a probe into this approach. Poverty-cum-below 50% of state average of student enrolment is one of the significant factors in deciding the social and educational backwardness. The Balaji decision presents the correct perspectives laying down certain significant criteria although the decision was subject to pulls and counter pulls in later decisions. 'Undignified' and 'filthy' occupations such as those of scavengers, washer men and fishing folk, may be indicators of social and economic backwardness. That a group comes from hilly and similar inaccessible areas is relevant factor although the habitation in rural and backward areas may not always be germane. The list of backward classes should be adopted even in the case of scheduled castes so that the economically well-off top creamy layers of a class may not reap the benefits. Only in this way, the ideals of social justice can be achieved.

The problems of the quantum of reservation of the backward classes and of the time span for such reservation are discussed in the Chapter VI. Here also it is pointed out that the earlier decision in Balaji is the better guide in fixing reasonable quantum of 50%. There is a reasoned ruthless criticism on decisions in Thomas and Vasanthkumar which jumped this limit. Compensatory discrimination will be a creative instrument to render social justice to weaker sections if the Balaji rules are observed.

Important decisions on Article 16 (4) are discussed in Chapter VII. The cary-farward rule had qualified the quantum rule. Promotion of backward classes after exempting them from passing the departmental tests will open the flood gate of indiscriminate practices of reservation for groups other than Scheduled Castes and Scheduled Tribes. Article 16 (4) is only a provision for protective discrimination and not one for guaranteeing fundamental rights to persons belonging to backward classes. Decisions to the contrary are criticised vehemently.

The position of women as a weaker section of the society demands the need for greater emphasis on gender justice. Chapter VIII looks back into the past practice and precepts. The alarming practice Sathi leaves one wonder how 'in the midst of scientific growth, an ugly aspect of religious fundamentalism has been rising steadily and has been making its forays into political arena.' Sthridhana meant in the past as a technique to make a woman economically independent has now boomeranged and become a practice for her eventual destruction.

Constitution guarantees woman rights to equality, protective discrimination and safeguards against exploitation. Chapter IX makes an inquiry whether these ideals protect the interests of woman in practice. The absence of the word 'sex' in Article 29 (2) is pointed out as a lacuna that enables the State as well as private management in discriminating woman by establishing educational institution for men only. A strong plea is made for amendment of the provision. The continued recognition of qualified polygamy under the Mohamedan law is a clear indication of the failure to realize social justice or gender justice. Plea for more stringent law on dowry is also mooted. The case law, culminating Shah Banu, on maintenance of Muslim divorsed woman was analysed thoroughly to hold that the Muslim women (Protection of Rights on Divorce) Act 1986 enacted to bypass the celebrated decisions is a misnomer.

Chapter X sums the conclusions and suggestions already made in other chapters.

## L.11. GOPALAKRISHNAN, N.S.–Protection of Property and Criminal Law. A Study with special reference to intellectual property–1989–Dr. K.N. Chandrasekharan Pillai.

Institution of property is a prerequisite for any legal system to function properly. Property relations play a pivotal role in the growth and development of a society. So, it is in the interest of society that property has to be protected. Protection of property can be effectively ensured through criminal law while civil law can lay down the rules governing the possession and holding of property. The protection afforded through criminal law to property in general and intellectual property in particular in the light of new technological development has been critically analysed with a view to deducing the governing principles.

The concept of property has to collect its meaning and content from the socio-economic political system. The vast technological developments which took place in the nineteenth and the twentieth centuries made property to be in search for new meanings. New items of property which thus came to be embraced by the concept of property demanded an overstretching of the traditional law. However, it was found inadequate to afford adequate protection to these new forms of property. This forced the law-makers to come out with new legal norms to protect these new forms of property. In this background the development of the new concept of property was examined.

It is found that having regard to the origin of the institution of property the concept of property has been identified as the satisfaction of the self of an individual in the society. It is taken as an extension of the personality of the individual. Though criminal law has not defined the concept of property, the courts in India have interpreted it to contain the emerging new forms of property. Thus a thing having any value to the individual has been recognised as property for affording protection. It was also made clear that the property sought to be protected must be in possession of a person or he must have ownership. This reinforces the basic theory of recognition of property as an extension of the personality of an individual.

It has been concluded after a detailed examination that our Constitution while recognises the need for protecting a certain limit of personal property for the proper development of the personality of the individual in the society, gives much stress on the need for retaining the property for the common good.

On examination the provisions in the I.P.C. are found inadequate to protect the new forms of property emerging out of the technological development especially in the area of intellectual property. So new legislation have been enacted with a view to protecting intellectual property.

It is based on the same philosophy of recognition of property, i.e., the extension of the personality of the individual, that intellectual property also received recognition. The intellectual labour of an individual is respected just like the physical labour spent for gaining property. Generally copyright, patent, designs and trade-mark are identified and grouped in this category. Examination of the origin and development of these items of property reveals that it is based on the public interest that these items are recognised and protected as property. While rendering protection to public interest adequate steps are taken to protect individual interest also. In cases of copyright, patent and design, in addition to the public interest of development of the society in cultural and industrial sectors, the intellectual labour of individual is also identified in recognising them as property. On examination of the new forms of property such as performerss' rights, computer programmes, man-made living microorganism etc., it is found that our laws are yet to catch up with the pace of technological developments. The laws not available in our country are found insufficient to protect these forms of property. This situation calls for a comprehensive legislation to contain the problems attendant with the protection of new forms of property.

Though it is well recognised that criminal law has a major role in protecting the society by affording protection to person and property, this has not been adequately utilised in case of intellectual property. Disregarding the public interest involved in recognising and protecting these forms of property legislatures as well as judiciary views them as private matter.

On examination of the existing provisions it is found that there is no uniform approach adopted towards different property offences. It is therefore suggested to provide compensation to the victims by giving a portion of the fine extracted from the offender. Even after identifying the technical nature of the offences committed in these areas, the traditional investigative machinery has been used to detect the crimes. This often resulted in acquittal of the offender for lack of evidence. The problem will be acute when we have to tackle the offences against the emerging new forms of property—video piracy, violations against computer programmes etc. of lot of expertise and training is required for detecting crimes in this area. So it is also suggested to create a special wing of investigating machinery.

In short a comprehensive legislation incorporating the principles discussed above including the special procedure and rules of evidence has to be enacted and implemented at the earliest so that the new forms of property could be afforded ample protection by the criminal law.

# Faculty of Social Science

## (Applied Economics)

### S.S.e.1. –ETHIRAJAN, V – Economics of Korai Mat Weaving in Thanjavur District 1983–Dr. K.C. Sankaranarayanan.

Cottage industries have got enormous employment potential as they are labour intensive in nature. Many of these industrial units do not require sophisticated machinery. These industries by their very nature use locally available raw materials with locally available skill and manpower. They do not cause air or water pollution. But in spite of all these benefits, the village industries are not provided with adequate finance and no meaningful attempt is made to make them effective of rural transformation.

Korai mat weaving is an important cottage industry in Thanjavur district. Most of the landless people living in the villages take korai mat weaving as a full-time occupation while others take it up as a part-time job to supplement their meagre income. This study examines the economic aspects of the Korai mat weaving industry in Thanjavur district.

**Method of Study.**

Data for the study were collected using a schedule. A total of 400 persons engaged in korai mat weaving in Thanjavur district is covered in the study.

**Scheme of the Study.**

The thesis is divided into nine chapters. The first chapter introduces the subject. The second chapter explains the employment potential of the industry. The third chapter is on localisation of the industry. This is examined in the light of Weber's theory on localisation. Chapter four discuss the different aspects of cultivation of the Korai grass. Chapters five to eight discusses the economic aspects of Korai mat production and chapter nine presents the findings of the study.

**Conclusions**

The korai mat weaving industry provides employment to a large number of agricultural workers during slack season. Though some people from the forward communities and from among the muslim have taken to korai mat weaving it is still dominated by the backward and scheduled caste communities. The weak economic position of those who are engaged in this profession gives room for large scale exploitation by the middlemen. To avoid this, cooperative societies should set up emporia at different places for providing an outlet for marketing the products of this industry.

The method of production is very primitive.. A little bit of innovation in the techniques of production will be of immense help to this industry.

## S.S.e.2. - VINCENT PANIKULANGARA-Industrial Laws in Transnational Corporations and Their Impact on The Economic Conditions of Labour: A Case Study of Pharmaceutical Industry in India-1983-

## Dr. K.C. Sankaranarayanan

Towards the latter half of this century a trend to make use of the instrumentality of law in order to achieve certain social objectives has emerged almost all over the world. Welfare legislation, accordingly, assumed significance in development efforts especially in the less developed countries towards achieving objectives such as reduction of in-equalities and the regulation of social relations. But experience shows that there is a wide discripancy between law and practice. Though this discripancy can be common, its nature and its extent can be influenced by the degree of militancy and determination of the beneficiaries of the enactment. Under conditions where the state implements a welfare enactment without the participation of any beneficiary group, the scope for such discrepancies is higher. Similarly, when the beneficiaries are weak and unorganised the chances for discrepancies stand to be higher. In situations where the beneficiaries of any welfare enactment are militant and determined the discrepancy between law and practice can be reduced considerably.

Therefore, the discrepancy in the case of an enactment enabling the extraction of surplus produce by the Goverment, can be fairly high while that in the case of an enactment intended to afford better conditions of work for the farm labour can be less. Similarly the discrepancy in the case of enactments concerning industrial workers can be less compared to that in regard to agricultural workers. However, with the collusion of a section of the workers, even in the industrial sector, the level of discrepancy can be engineered. That is to say, if the management and the permanent section of the workers, strike a deal, it may be possible to reduce the descrepancy in the case of the permanent workers, while aggravating that in relation to the non-permanent ones.

This study proposes to verify the above hypothesis relating to labour legislation in the industrial sector. Here, there are as many as fifty enactments of the Central Government alone, since 1920 (except for the Fatal Accidents Act enacted in 1855). These legislations indicating the growth of this branch of law over a period of more than half a century cover a wide spectrum of interests of workers, both individual and collective in different areas of employment. However, this study relates mainly to (a) Trade Unions Act, (b) Industrial Employment (standing orders) and (c) Industrial Disputes' Act.

### Methodology.

The study is partly discriptive and partly analytical. Data for the study were collected mainly through field investigation and from official record.

### Scheme of the Study.

The study consists of eight chapters. The introductory chapter discusses the discripancy between law and practice. The second chapter provides a review of literature on the impact of transnational companies on labour in host countries The third chapter deals with transnational companies in terms of econimic resoruces and the repatriation of profits. The fourth chapter gives a brief survey of the industrial laws in India. The fifth chapter discusses the different aspects of the Pharmaceutical industry in India. Chapters six and seven present the practices relating to labour in transnational companies in the pharmaceutical industry. The concluding chapter discusses the impact of the discripancy between law and practice on the economic conditions of labour.

### Conclusion

It follows from this study that the labour practices of TNC$_s$ can produce adverse impact on this industrial relations in India. Such adverse impacts will not be confined to the economic conditions of labour alone, but it can extend to other areas such as the consolidation and the expression of the class interests of the workers.

The classification of workmen into permanent and non-permanent in terms of both economic gains and job status can lead to a differentiation and polarisation among the workmen. In the event of such a development, the permanent workers who are better off and the favourites of the management can turn out to be more status quo oriented and prestige-conscious and less concerned about the values and interests of the workers as a whole. On the other hand the less privileged non-permanent workers are made submissive by the insecurity of their jobs.

## S.S.e.3. AJITH KUMAR, N.-The Impact of the Kerala State Bamboo Corporation in the Development of the Bamboo Industry in Kerala-1985-Dr. Jose T. Payyappally.

The Kerala State Bamboo Corporation was established on 13th March, 1971, by the Government of Kerala as a promotional agency to provide succour to those people depending on bamboo and reeds for their livelihood. Bamboo is a kind of grass and is regarded as the tallest of all grasses. Reeds are a form of thornless bamboo seen only in the forests of Kerala and have a Kerala-oriented botanical name Okhlandra Tranvancorika. A large number of people cut these reeds from the forests and make mats an baskets out of them. These commodities have a wide market and an inelastic demand.

The reed cutters and mat weavers of Central Kerala were being subjected to ruthless exploitation by certain middlemen who made vast profits out of the products they made. Moreover, the forest wealth of Kerala, consisting of all types of coagrass items, was not being utilised to the maximum. Therefore, to save the poor folk from exploitation and to make full use of the forest resources the Kerala State Bamboo Corporation was established.

The Administrative Office of the Corporation is at Angamaly, a municipal town in Central Kerala and its Registered Office is situated in Trivandrum. It is operating on a no-profit no-loss basis. From 1971 to 1978 it functioned as a subsidiary of the Handicrafts Development Corporation and in 1978 it was made an autonomous institution.

### Objectives of the Study

The Corporation's main duties are supplying the raw materials to the bamboo workers and making arrangements for the marketing of the finished products. How far the Corporation has succeeded in carrying out these main duties is the most important objectives of this study.

Then we want to analyse the role played by the Corporation in promoting this industry and to what extent it has taken the lead in the development of cottage industries based on bamboo and reeds in Kerala State.

The third objective is to highlights the problems faced by the Corporation in the discharge of its functions and to study the shortcomings in its working.

Finally it is proposed to make recommendations to tone up its functioning and offer solutions to the manifold difficulties which it faces.

## Hypothesis

1. The products of the bamboo industry have a wide market within and outside Kerala. But the benefits of this market have not reached the primary producers.
2. The Government of Kerala has not given due recognition to the vast employment potential of this industry.
3. In India the rate of capital formation is very low. It is all the more true in Kerala, where percapita saving is quite low and the density of population is the highest. In the case of the bamboo industry the capital investment is very small and the labour content is very high. Threfore any programme of the State Government to reduce unemployment with minimum investment should give this industry a prominent place.
4. The bamboo mat can be used to produce "bamboo board" which is an effective substitute for plywood. The demand for plywood and wood-based panels for the year 1980 was of the order of 155 million cubic metres and by 1990 it is estimated to go upto 300 million cubic metres. At present the world production of plywood is 90 million cubic metres and India's contribution is 5 lakh cubic metres. This gap cannot be bridged by plywood and other existing wood-based panel products. Only an alternative and attractive material like bamboo mat can meet this challenge.
5. The Kerala State Bamboo Corporation, the working of which greatly influences this industry, is functioning at a low level of efficiency. Improvements in its functioning will go a long way in rejuvenating the bamboo industry.

## Methedology

No study has yet been conducted on the Bamboo Corporation in particular and the bamboo industry in general. Therefore the Survey Method and the Interview Method had to be relied upon. The population size is taken as 12,000. This consists of reed cutters, mat weavers and others depending directly and indirectly on this industry. The number was arrived at after detailed consultations with the Corporation officials. The corporation has 57 depots. Around 200 to 400 families are attached to each depot. As all persons doing bamboo work are eligible for registration in these depots, the exact number attached to each depot is difficult to calculate. Taking into conisderation these aspects, the population size was fixed at 12,000. The survey covered 5% of this population size. The Random Sampling Method was followed and 600 families were surveyed. Twelve main centres were identified for this purpose. As the accurate number of families in each centre dified calculation, a rough approximation was made and 5% surveyed.

To study the working of the Corporation the 'Report and Accounts' from 1977-78 to 1982-83 were requisitioned. The project report of the Corporation's diversification project called the "Bamboo Board Project" was perused. Extensive interviews were conducted with all the important officials of the Corporation and those connected with it earlier. For want of documentary evidence, newspaper reports were used to substantiate facts.

## Scope of the Thesis

Till it gained autonomy in 1978 the Corporation followed a trial and error method inits functioning. From 1977-78 onwards it started publishing in book from its annual 'Report and Accounts' in a systematic manner. Therefore the study covers the period 1977-78 to 1982-83.

The Corporation deals with only reeds. It is authorised to develop all industries dealing with coagrass items, i.e. bamboo, reeds, cane and rattan. But the workers attached to the Corporation make use of only reeds as they are better suited to make mats than the other three grasses. Hence the Corporation is concerned with only reeds, though it is called "Bamboo Corporation" and the workers depending on it are known as "bamboo workers".

Most of the families depending on reeds reside in Central Kerala. There are a few families in North and South Kerala. Until very recently these families were outside the Corporation's influence. Hence the impact made by the Corporation on their lives is yet to be fully realized. Therefore the scope of this thesis is restricted to those persons who are attached to the Corporation since its inception and particularly since it gained autonomy.

## Plan of the thesis

The thesis is divided into six chapters and the following are the chapter headings.

1. Introduction
2. History of the Bamboo Inudstry in Kerala
3. Working of the Bamboo Corporation
4. Impact of the Corporation
5. Problems and Shortcomings
6. Conclusions and Shortcomings

The first chapter introduces the subject of study. It explains why the study was undertaken and the circumstances that led to the establishment of the Kerala State Bamboo Corporation.

In Chapter II the evolution and history of the bamboo inddustry is tranced. In this chapter the reasons for considering the bamboo industry as a traditional cottage industry is explained. The growth of the industry from a side business for self-consumption to a full time occupation is also narrated. The conditions of the industry before and after the World War II are historically analysed. The factors that led Angamaly being chosen as the headquarters of the Corporation and its present set-up is also briefly reviewed here.

Chapter III is concerned with the working of the Corporation. The management structure and the objectives of the Corporation are incorporated in this chapter. The financial management of the Corporation is also discussed here. The main functions, viz., the collection and distribution of reeds, puchasing of mats from the mat weavers and the marketing of mats are analysed. The price policy, Research and Development' activities and the welfare measures of the Corporation are the other aspects included in this chapter.

Chapter IV analyses the impact made by the Corporation on the bamboo industry. Here its most notable impact in the field of "Research and Development", viz., its diversification project called the "Bamboo Board Project" is analysed. The important role played by the Corporation in supplying effectively the rawmaterials to the mat weavers is also discussed. Its efforts for the widening of the markets of the products of the bamboo industry are explained. The far-reaching consequences of its welfare measures are also discussed here.

In Chapter V the following problems faced by the Corporation and the shortcomings in its working are elucidated. The main problem it faces is the shortage of raw materials. This problem is further aggravated by the Governmental indifference. The use of outdated labour-intensive technology is binding its hands and discouraging it from introducing new techniques. Besides, labour problems cripple its very working. Though it has no longer the problem of lack of markets, it now faces the difficulty of supplying mats in sufficient quantities to its customers. Above all red tapism is an important shortcoming of this institution. Moreover, the Corporation has undertaken schemes far beyond its means like the "Bamboo Board Project". This chapter also analyses how increasing non-development expenditure and escalating liabilities are hindering its smooth functioning.

Chapter VI summarises the conclusions and recommendations of the study.

## Conclusions and Recommendations

## SECTION I

In this section we have come to the conclusion that the most important problem faced by the Bamboo Corporation is the shortage of raw materials. Recommendations have been made as to how this problem can be solved. It has been concluded that this problem has both quantitative and qualitative aspects.

First the quantitative aspect is discussed. The Corporation has the permission of the Government to cut 25,000 tons of reeds annually from the forests of Kerala. This is far from sufficient. Hence it is recommended that the reed quota is raised to 36,000 tons per year. The annual output of reeds in Kerala has been estimated as 3 lakh tons. Of these, 1,89,000 tons are allotted to the Hindustan Paper Corporation, 85,000 tons to the Punalur Paper Mills and 25,000 tons to the Bamboo Corporation. The contractors of the first two factories cut the reeds indiscriminately as they are not concerned with the ripeness of reeds. But to weave mats ripe reeds are a must. The reed cutters of the Corporation indulge in "select felling". Owing to the unplanned cutting of reeds by the other two, the Corporation finds it difficult to get its annual allotment. To prevent this situation, it is suggested that the forest ranges containing reeds be divided among the principal reed users. There are mainly 15 reed forest ranges in Kerala. Six can be given to the H P C, five to the Punalur Paper Mills and four to the Corporation. They should also be given the exclusive responsibility of looking after these ranges and this would go a long way in solving this problem of reed shortage.

This problem has also a qualitative aspect. According to quality and size reeds are marked AVI, AV, AIV, AIII, AII, AI, A, B upto M. But only reeds upto the size B are fit for mat making. Very often the Corporation gets inferior quality reeds which can be used to make only baskets and other wares. Therefore it becomes difficult for the mat weavers to dispose off these products. This problem can be solved if the Corporation arranges the marketing of all products made of reeds and not mats alone.

### SECTION II

The positive role which the Government should play in helping the Corporation to overcome its problems is discussed here. A majority of the people depending on reeds are Harijans. The Kerala State Development Corporation for Scheduled Castes and Scheduled Tribes is established for the upliftment of the Harijan groups. However, its assistance has reached very few Harijans depending on reeds. This condition has to change. Government subsidy for the economically weaker sections seems to have bypassed this folk. The only loans these people get are those sanctioned by the Bamboo Corporation. Government subsidy would also help these people to get loans from nationalised banks. The poor repaying capacity of these people has made the nationalised banks hesitant to sanction loans even under the "Differential Interest Rate" system.

The Kerala budget of 1982-83 declared bamboo industry as a "distressed traditional industry". But the benefits of such an industry are yet to be released. The Corporation has launched several welfare measures. The most important is the "Supply Incentive Scheme". This is a scheme to pass on a part of the profits of the Corporation to the workers. This scheme existed even during those years in which the Corporation was running on loss. As this is the only scheme which benefits all the reed workers it would be in the fitness of things for the State Government to completely subsidise this scheme. Finally, for its commendable work in the field of welfare the Government should give the Corporation an annual grant of Rs. 5 lakhs for welfare measures alone.

### SECTION III

The necessity to introduce modern technology to improve the quantity and quality of output is emphasised here. Owing to the high percentage of depreciation and low longevity it is difficult for the Corporation to meet its supply commitments. To improve the level of technology the starting of a new "Research and Development" division is recommended. Training programmes should be launched with the help of the State Industries Department. Better training and a policy of introducing modern technology will help in the introduction of the factory system in this industry. A time-bound programme of ten years for modernising the industry under the auspices of the Corporation would definitely help to pull out this industry from the shackles of tradition.

### SECTION IV

At present there is no systematic and scientific wage system in the bamboo industry. Though Kerala is in the forefront regarding agrarian reforms, traditional industries in general and the bamboo industry in particular have had very few wage reforms. This has resulted in frequent confrontation between the workers and the Corporation's management.

A proper price policy has to be introduced. Now there is a wide disparity between the buying price and the selling price of mats. While the Corporation pays the mat weavers Rs. 2.25 per mat, its selling price is Rs. 3.45. The workers demand that they should get 50% of the price of mats as wages. They are given reeds on credit and when they sell the mats to the Corporation the cost of reeds is deducted and the balance paid. In the present circumstances, if the Corporation reduces its non-development expenditure it will be in a position to raise the buying price of a mat to Rs. 2.50. A broad-based price policy would also help in building up reserves which would enable the Corporation to introduce more welfare measures.

To help the traditional fishermen there is a Fishermen Welfare Corporation in Kerala. This is doing commendable work especially in the field of housing. With more resources the Bamboo Corporation also would be in a position to take the lead to establish a Bamboo Workers Welfare Corporation which is the need of the hour.

### SECTION V

To encourage the marketing of commodities several Marketing Boards have been established both at the state and at the national levels. The Cardamom Board, the Tea Board, the Coir Board etc. have helped their respective products to get both a national and an international market. It is viable to start a Bamboo Marketing Board since there is a heavy demand for its products. With the commissioning of the Bamboo Board Project its establishment becomes all the more important.

### SECTION VI

The Co-operative Movement is yet to make much headway in this industry. The reorganisation of this industry along co-operative lines is suggested. The example of the Kerala Dinesh Beedi which, when organised along co-operative lines, emerged as the premier beedi manufacturing unit, is cited. The problems faced by this organisation before the introduction of the co-operative set-up were similar to the ones faced by the bamboo workers now. Therefore through the introduction of co-operative ideas and by making the Bamboo Corporation the apex body, this industry should be reorganised. This will encourage more worker participation in production, eliminate employer-employee relationship and pave the way for greater cordiality and productivity.

### SECTION VII

To improve the efficiency of the Corporation an overhauling of the administrative machinery is suggested. The Corporation does not have a General Manager since 1978. This post has to be revived. The Chairman and Directors are politicians. They have little knowledge about the problems of the industry. Therefore this policy should be discontinued.

For administrative convenience the Corporation has been divided into five divisions - Reeds, Mats, Sales, Accounts and Storage and Despatch. To improve efficiency the Mats and Storage and Despatch divisions should be amalgamated. Side by side a new division under the name "Research and Development" manned by technical experts should be started. This would give the Corporation a new orientation.

### SECTION VIII

To improve the lot of fishermen the Government of Kerala has established 222 fishermen villages in the State. These villages have provided a lot of relief to the traditional fishermen. "Bamboo worker villages" along the same lines is suggested. As these workers also live in clusters in the rural areas just like the poor fisherfolk, it is easy to organise them.

### SECTION IX

The Integrated Rural Development Programme, introduced in the Sixth Plan, had little impact on the bamboo workers. The Central Government has drawn up a plan to spend Rs. 362 crores in the villages of Kerala under this programme in the Seventh Plan period. The Corporation should make efforts to bring to the attention of the concerned authorities the necessity to launch this programme in a big way to assist the bamboo workers.

### Contribution of the Researcher

No study was undertaken till now in this field and hence this is an original work. Utmost care was taken to make this study useful to the bamboo industry. Finally, shortcomings were identified and solutions recommended for the innumerable problems the industry faces.

## S.S.e.4. SHAM BHAT, K.–A Case Study of the Finance of the Selected Panchayats in Ernakulam District –1986–Dr. K.C. Sankaranarayanan.

### Introduction

One of the directive principles (Art. 40) of Indian Constitution States that "the State shall take steps to organise village panchayats and endow them with such powers and authority as units of self-government".

But local government in India functions under the serious limitation of resources constraints. Consequently they fail to fulfil the objectives of economic growth.

Objectives of the Study:

The objectives of this study are

(i) to enquire into the financial aspects of the selected Panchayats in Ernakulam District.

(ii) to analyse the income and expenditure pattern of selected and district Panchayats during 1969-70 through 1983-84.

(iii) to suggest steps to be taken by the Panchayats for the proper utilisation of resources and for increasing the availability of resources.

### Methodology

Out of the 86 Panchayats that exist in Ernakulam district Five Panchayats were selected for the study on the basis of certain pre-determined criteria. The Panchayats which satisfied these criteria are Elamkunnapuzha, Narakkal, Pallipuram, Kalamassery and Eloor.

Data for the study were collected from the administrative reports of Kerala Panchayats and the administrative reports of District Panchayats. These data were supplemented by interviews and discussions with the officials and elected members of the Panchayats.

### Scheme of the Study

For the purpose of analysis the thesis is divided into nine chapters. The first chapter gives an introduction to the subject of the study. It also highlights the problem, objectives, hypothesis and methodology. A review of literature also forms part of this chapter.

Chapter two is on the evolution of Ernakulam district. It also examines the socio-economic profile of the district with reference to the selected Panchayats.

Chapter three provides the theoretical framework to the study and chapter four explains the pattern and trends of total and per capita expenditure of selected and district Panchayats.

Chapter five presents a detailed analysis of various heads of expenditure and the extent of misutilisation of Panchayat funds.

Chapter six analyses the pattern and trends of total and per capita revenues and tax and non-tax revenues. It also examines the tax potentials of the selected and District Panchayats. Chapter seven explains the pattern and trends of various heads of revenue and the possibility of additional sources of revenue to the Panchayats.

Chapter eight presents the regression analysis as per capita expenditure and per capita income of the selected and District Panchayats during the period of study. Chapter nine presents the conclusions and recommendations of the study.

### Conclusions of the Study

The total expenditure of selected and district Panchayats increased continuously during the period of study. There was no attempt from the side of the Government to bridge the gap ,of inequality of regional development.

The non-development expenditure is increasing at a faster rate than the development expenditure.

All selected and district Panchayats have given top priority to public works in development expenditure.

There was no attempt from the side of any Panchayat to start any school, reading rooms or libraries of their own. But the Panchayats have given considerable attention to health care activities.

The revenue of the Panchayats have increased considerably.

### Recommendations

1) In order to attain the balanced regional development the transfer of resources from State Govt. to the Panchayats should be based on the deficiency of per capita resources.

2) In the interest of the development of the village economy, Panchayats should follow long-term planning in respect of allocation and spending of resources.

3) All attempts should be made to reduce the escalation of administrative expenditure.

4) Building tax should be rationalised by introducing proper classification of buildings.

5) In view of the rising cost of road maintenance, there is an urgent need to provide adequate share of motor vehicle tax by the State Government to the Panchayats. The proceeds should be shared in proportion to the mileage of the Panchayat roads and the volume of motor traffic making use of such roads.

## S.S.e.5. HARIKUMAR, S.–Impact of Agricultural Credit in the Agricultural Development of Kuttanad–1987–

**Dr. Jose T. Payyapally**

The objectives of this study have been to examine the interlinkages of land, labour, credit and commodity markets, to analyse capital formation in agriculture, to examine the demand and supply of agricultural credit and interlinkage between formal and informal credit markets, to analyse the impact of agricultural credit on output, land utilisation and employment etc.

The study has been based on the empirical results obtained from a three-tier survey viz., household, agricultural money lenders' household, and financial institutions. The thesis has been divided into seven chapters. The introductory chapter highlights the problem, objectives, hypotheses, methodology, limitations and theoretical framework of the study. The subsequent chapters explain the nature of capital formation in agriculture, demand for agricultural credit, relative importance of credit agencies, major sources of credit supply, informal credit transactions in agrarian economies etc.

The recommendations include:

1) Banks should try for the inculcation of saving habits from the borrower - farmers besides providing credit at a cheaper cost. Schemes embedded with built-in-saving mechanism may work out more effectively.

2) Gold loans to be treated as production-cum-consumption credit and accordingly their interest charges to be reduced. Loans to be made available at the appropriate time.

3) Proper integration to be made between quantitative and qualitative aspects of agricultural credit.

4) Village committees to be formed for supervision and recovery of loans.

## S.S.e.6. MATHEW GEORGE–Price, Profitability and Employment in the Handloom Industry in Kerala–1987–

**Dr. K.C. Sankaranarayanan & Dr. V. Karunakaran**

### 1. Introduction

The handloom industry in India has a very long history spanning over centuries. Handloom spinning and weaving were the main occupations of the people in ancient India. Indians exported handloom fabrics all over the world and had good reputation. But unfortunately, this industry has been declining owing to so many historical and other reasons.

In Kerala, hand weaving was a traditional occupation of Chaliyans, the main weaving caste. It employs more than 1.5 lakh people. This industry is mainly concentrated in Cannanore, Kozhikode and Trivandrum districts. At present, this industry is facing severe crisis due to increased cost of production, marketing difficulties and working capital problems.

### 2. Statement of the Problem

The present study is on the nature and problems of handloom industry in Kerala. The problems of the industry are mostly in the nature of low earnings of the workers, under utilisation of the existing capacity and low profit in its various sectors. The majority of the handloom co-operative societies are either dormant or facing liquidation. The income and employment of weavers are so pitiably low that they are living in utter poverty and starvation. Frequent price fluctuations of yarns, dyes and chemicals increase the cost of production and reduce the profitability. Consequently handloom fabrics are not able to compete with mill cloths and powerloom products. Accumulating the unsold stocks in the godowns of co-operative societies and with master weavers has become the practice of the day. Spinning mills in Kerala are producing only lower counts of yarns. So, handloom industry has to depend on textile mills in Tamilnadu for higher counts of yarns. They create artificial scarcity and increase the prices exhorbitantly. Wage rates prevailing in Kerala are higher than those in Tamil Nadu. So rich master weavers are migrating to Tamil Nadu and exporting the fabrics, under the label 'Kerala Handlooms.' Governmental efforts to tackle the crisis by way of rebates and subsidies are found to be futile.

### 3. Importance of the Study

It may be pointed out that the handloom industry has great potential for the utilisation of human resources. In a country with considerable man power and a high rate of unemployment, any investment that can utilise idle human resources is welcome.

### 4. Need for the Study

Several exhaustive studies have been made about the mill sector. The capital investment, labour productivity, labour welfare, pricing policies have all been studied in detail all over the country. There have been studies of the handloom sector, by State Government and individual researchers. However, no empirical study has been made on price and profitability in the industry. The Governmental studies have been in the nature of surveys, mostly concentrated on the handloom co-operative societies. The sector as a whole has not been properly evaluated and therefore an attempt has been made to fill up this lacuna. The study also attempts to make a detailed analysis of the uniqueness of this industry and other important aspects such as organisation, functioning, and problems.

### 5. Methodology

The data for the study were collected in the following manner.

1) Primary data relating to origin and development of handloom weaving in Kerala were collected from historical records.

2) In order to study the working of co-operative societies, they were surveyed with the help of an appropriate questionnaire.

3) To study the income and employment of weavers in various sectors, yet another survey was conducted.

4) The working of the Kerala State Handloom Development Corporation and Intensive Handloom Development Projects was reviewed after referrring government records and consulting the officials.

5) An extensive survey of literature enabled the co-ordination and analysis of data and information collected from various sources.

### 6. Plan of the Study

The origin and development of handloom weaving in Kerala is explained in Chapter I. In Chapter II, the structural changes that had taken place due to colonial penetration and growth of cotton mills are analysed. Chapter III analyses employment of weavers distribution of looms and organisation of the industry. The impact of price fluctuations of yarns, dyes and chemicals on the profitability of the industry is examined in Chapter IV. Income and employment of weavers in various sectors are also studied in the same chapter. The marketing difficulties, working capital problems and various aspects of rebate schemes on co-operative societies constitute the content of the Vth Chapter. Chapter VI, reviews the working of Intensive Handloom Development Projects. Finally, research findings

and recommendations are given in Chapter VII.

### 7. Conclusions

1. In ancient times a specific mode of production prevailed in India which provided full employment to the people. Indian handloom fabrics had worldwide demand in those days. This industry started to decline since the industrial revolution and subsequent technological changes. In addition the introduction of money economy, free play of market forces and dominance of finance capital gave mortal blow to this industry. When handlooms started consuming mill made yarn, the net effect was the dependency of this traditional industry on the organised capitalist cotton mill industry.
2. The ruling classes which protect the interests of capitalists in cotton textile industry, controls and restricts the development of handloom industry. Yet this industry survived only because of the consumers preference to handloom fabrics.
3. Propagation of Khadi and Village industries is the crux of Gandhian economics. If the people boycott the millmade cloths, handloom industry can be revived. Being a traditional industry, it protects the ecology and ensures full employment of human resources. This industry can solve the unemployment problem in India to a great extent.
4. Majority of the handloom co-operative societies in Kerala are facing severe financial crisis due to marketing difficulties. Frequent price fluctuations of raw materials increase the cost of production and reduce the profitability of the industry.
5. Since the wage rates prevailing in Kerala is higher than that in Tamil Nadu, rich master weavers are migrating to Tamil Nadu and exporting fabrics in the label, "Kerala Handlooms". So an all India wage policy should be introduced so as to control the migration.
6. Government efforts to revive the industry by way of rebates and subsidies are found to be futile.
7. Handloom production, marketing and employment can be considerably expanded, as may be suggested, if we introduce the system of uniforms to school children and employees concerned with handloom fabrics.

## S.S.e.7. RAJASENAN, D.–Fishing Industry in Kerala-Problems and Potentials–1987–Dr. K.C. Sankaranarayanan.

### Introduction

Fisheries provide one of the richest renewable natural resources. From time immemmorial fishing has been the traditional occupation for a large segment of the population inhabiting on the sea coast.

To exploit the fishery wealth the fishermen devised several techniques. Some of these techniques have created certain problems both for the administration and to the traditional fishermen.

The thesis analyses the problems faced by the fishing industry in Kerala, especially after mechanisation.

### Objectives of the Study

The objectives of the study are:

1. to analyse the economics of operation of the mechanised fishing and to

discuss the important problems and issues of this sector.

2. to suggest various conservation measures based on the principle of fishery management regulations to avoid over fishing of the commercially important species.
3. to recommend the feasibility of fish culture activities as a source of income and employment to the fishermen community.
4. to suggest with the help of relevant data to the concerned authorities various measures for planning and implementation of development programmes for the benefit of the most exploited people of this sector.

**Hypothesis**

1. Fish catch levels have remained stagment during the past in spite of various developmental programmes.
2. Mechanised fishing through out the year is uneconomic in terms of cost and yield.
3. Fish culture industry can be developed for generating income, employment and foreign exchange earnings to the state.

**Methodology**

The study is both analytical and descriptive. The data for the study were collected in the following way.

1. Primary data for analysing the economics of mechanised fishing were collected for zix quarters from the maximum concentrated mechanised fishing centre of Sakthikulangara-Neendakara belt.
2. To study the importance and potential of fish culture activities data were collected from the experimental fish farms of the Kerala Agricultural University, Ernakulam. Production function method is used to evaluate the economics of culture operation.
3. Secondary data were collected from various Fisheries Research Institutes and the Fisheries Department, Government of Kerala to derive the income trends for the various gear types in Kerala.
4. Secondary data regarding the fish production trends of 28 quarters were collected to find out the seasonal variations based on time series forecasting models.
5. Secondary data from MPEDA were also used to analyse the importance of marine products export in the State of Kerala.

Data collected from different sources were supplemented by holding discussions with the fishery experts of different research institutions.

**Limitations**

The study is subjected to many limitations. The major limitation is the availability of reliable and accurate data with reference to the economic performance of the industry. The mechanised boat owners invariably try to understand the catch and value of the products and overstate their economic problems. There is wide variation in the catch data of the artisanal sector from one source to another.

**Plan of the Study**

Chapter I gives the origin and development of the fishing industry, its methodology, scope and objectives of the various developmental issues. Chapter II examines the use of the various production methods and technology. Chapter III presents the production trends, iterative behaviour of fish production based on harmonic analysis of time series model and ARMA modelling. In Chapter IV the development and growth of fish processing and other subsidiary industries have been analysed. Chapter V presents the importance of transportation and marketing for the minimum spoilage and waste of fish products.

The present problem of the fishing industry, ie., the conservation and management regulations are highlighted in Chapter VI. In Chapter VII, the structural and changing pattern of Kerala's marine product export is analysed. Chapter VIII presents two case studies, one relating to the mechanised fishing and its economics based on cost-benefit analysis, discounting method and statistical coefficient of seasonal fishing ability. The other relates to the economics of fish culture activities based on Cobb-Douglas production function.

The last chapter presents the summary, findings, and recommendations of the study.

**Recommendation and Conclusion**

1. Traditional fishermen, who are socially and economically backward should be given due importance in the planned fishery development of the state by providing credit, marketing and other infrastructural facilities.
2. In order to safeguard the traditional fishermen fishing zones for the traditional and mechanised fishing should be strictly enforced.
3. The present number of mechanised boats are more than optimum for exploiting commercially important species. Mechanised fishing licenses should be stopped and the existing excess boats should also be deployd to diversified fishing activities.
4. Mechanised fishing is profitable only in certain seasons and this being the much controversial months of June-July-August. So banning of trawling during these monsoon months will be suicidal to the mechanised fishing industry.
5. To ensure better and reasonable prices for the fishermen's produce, marketing societies are to be organised by the fishermen themselves.
6. Brackish water fish culture has immense scope in Kerala for generating income and employment to the fishermen. This would also help to earn more foreing exchange at a time exportable species are dwindling from the capture fisheries.
7. Motorisation of the traditional sector helps to earn more incomes to the poor fishermen. So infrastructural facilities must be provided to them by the state for the development of motorisation.

## S.S.e.8. RAVINDRAN, A.M.–Impact of Gulf Money with Particular Reference to Chawghat, Trichur District, Kerala–1987–Dr. V. Karunakaran and Dr. K.C. Sankaranarayanan.

The study is an attempt to analyse the impact of inward remittances from the gulf countries on the economy of Kerala. The study is made with particular reference to Chawghat Taluk in Trichur District.

**Objectives of the Study**

The objectives of the study are

(i) to estimate the quantum of remittances made by the emigrants.

(ii) to examine the pattern of utilisation of remittances
(iii) to analyse the impact of remittances on the non-emigrant households, and
(iv) to study the overall impact of remittances on the economy of Kerala.

### Methodology

The study is primarily based on the sample survey conductedd in two Panchayats. This was supplemented by data published by different agencies.

### Scheme of the Study

The thesis is divided into 10 chapters. The first chapter gives an introduction to the subject. It also defines the problem, objectives and methodology. Second chapter gives a brief sketch regarding the dimensions of Indian emigration. Chapter three discusses the process of emigration. Chapter four analyses the characteristics of emigrants from the study area. Chapter five is on the inflow of remittances. Chapters six and seven present the impact analysis. Investment prospect of non-resident Keralites is the theme of chapter eight. Chapter nine discusses the future of emigration from Kerala and chapter ten presents the findings of the study.

### Conclusions

Inward remittances into India have been considerably rising since construction boom started in the gulf countries. This has helped to ease our balance of payments situation. Most of the emigrant households were very poor. But once they began to receive foreign remittances their life styles have changed. Money was lavished on palacial buildings.

Inward remittances also increased the practice of dowry. This has adversely affected the non-emigrant households. A mojor share of the remittances received were spent on unproductive investments. It has also resulted in conspicous corruption.

## S.S.e.9. ANTONY, C.A.–ENVIRONOMICS–A Financial Estimate of Environmental Pollution Control Abatement Schemes in Eloor–Edayar Industrial Belt–1988–

## Dr. K.C. Sankaranarayanan

### Introduction

A major problem of contemporary economic and social policy is the extent to which industrial pollution should be controlled. To this end a substantial amount of academic research has been carried out across the whole spectrum of science. Much theorising and research have still to stand the test of time since environmental issues are essentially long term and there is considerable uncertainty in many natural and applied sciences about pollution and its control.

In the sphere of economics, substantial advances have been made at the macro level concerning problems such as economic growth and the quality of life, but there are still many under-researched areas at the micro level. Little work has been done outside the US in the impact of pullution controls on firms and industries in general, and small and medium sized firms in particular.

Pollutants have clearly been with us since time immemorial and have, to a large extent, been tolerated as a fact of life. To a certain extent the increase in living standards in western economies which have occurred during the 19th and 20th centuries have merely exacerbated the problem and that pollutants that have always existed have become a much more explicit feature of life.

A priori there appear good reason for looking at the impact on firms of government controls and public awareness of pullution. Specifically, these may result in cost the firm has to bear, directly as result of the emission of waste product, or alternatively the firm may be prevented from using an input that, under other circumstances, it would choose to use. The prevention of firms using certain inputs and for charging for wate outputs necessarily constraints freedom of choice and may affect the efficiency of the firm at that point in time; this may result in an increase in prices, reduction in employment or reduction in product quality. The extent to which these phenomena occur depends on the relative importance of pollution control costs in production. The size and nature of the polluter's output of waste also has to be determined, although sometimes it may be necessary to use inputs as a proxy indicater of outputs, for instance when trying to quantify airborne emissions. This type of data is not available from published sources and consequently it had to be collected on an individual firm basis through the use of questionaires/schedules and interview to generate the information.

Economists interest in the problem of pollution stems principaly from three sources: firstly, the existence of externalities; secondly, the debate concerning the cost and benefits of economic growth and finally, the incidence of pollution control on the firm, the consumer and labour. The eesence of the debate on externalities (the divergence between private and social costs) has been that production and sometimes consumption of goods uses acarce resources, some that can be bought (labour/raw materials, etc.) and some that result from common property for which, in most instances, no price is paid (for example, fresh air and clean water), since they are used by the community as a whole and there is no market in them. Two problems arise because of this state of affairs; i (i) there is the possibility of over usage and (ii) because the resources are common property, the consumption of one section of the community may well affect the welfare or satisfaction of another group, thus the smoky chimney pollutes the air others breath and the chemical affluents kills fish in the river or, indeed, one firm's pollution may add to another firm's production costs. Technically this means that the individuals utility function contains arguments, some of which he has under his control and some that are interdependent with the production and consumption processes of others. The main problem that economists have attempted to solve in this area relates to what amount of pollution is consistent with an optimum allocation of resources and how can this optimum state of affairs be arrived at. Closely connected to these issues, which have typically been investigated at the micro level (firm, individual or industry), is the debate over whether or not economic growth is a desirable macro-economic objective and exactly how the level of national output can be calculated to take account of non-market activities (like some forms of leisure) which rely on the use of common property resources and do not command a market price. Finally, pollution abatement measures are taxes on the firm's operations and affect the level and nature of these operations to some extent; how the firm reacts to these controls and what impact they ultimately have on the firm's prices, output, employment and technical progress represents another important area where economics is able to make some contribution.

The thesis under reference is a financial estimate of environmental pollution control and abatement schemes in Eloor-Edayar industrial belt. The Eloor - Edayar industrial belt is the most polluted area in the state of Kerala.

The study analyses the financial, economic, social and political implications of the polluted environment in the project area and various impacts of pollution and its control and abtement measures aimed at protecting the environment. A financial estimate is made accounting for different categories of costs and benefits involved in the abatement and control of pollution.

The specific objectives of the study are:

i) to define invironmics and discuss important issues and problems of this new branch of economics
ii) to conduct an 'Environment impact assessment' of Eloor-Edayar industrial belt considering the economic, social and other aspects of the problem
iii) to judge the economic feasibility of protecting the environment of the project area by making a financial estimate taking into account the various costs and benefits involved in the process, and
iv) to make available relevant data to the appropriate authorities for decision-making and implementing various environmental protection measures in problem area and elsewhere.

Data for the study are collected both from primary and secondary sources. The primary data were collected with the help of four schedules.

The major limitations of the study are:

(i) Non-quantifiability of most of the environmental aspects.
(ii) Non-availability of certain critical information on account of gaps in knowledge, especially with respect to the impacts of some of the pollutants, and lack of cooperation from official agencies entrusted with environmental protection.

For the purpose of analysis the thesis is divided into nine chapters.

The first chapter is an introduction to the subject of study. Chapter two makes a brief review of environmental literature and the measures adopted at the global level to protect the environment. The protection of national environment from the ancient till the present forms the content of chapter three. The first three chapters provide a background to the issues analysed in the thesis.

The theoretical issues cocerned with 'Environmics' are reviewed in chapter four. The theoretical issues involved in estimating the costs and benefits of environmental protection constitute the theme of chapter five.

The state of environment in Eloor-Edayar industrial belt and the impact analysis of pollution of the area are discussed in chapters six and seven respectively. Chapter eight makes the financial estimate of environmental protection of the project area. Chapter nine presents the findings of the study.

### Conclusions

(1) The environment of the project area is heavily polluted.
(2) The pollution impacts are spread to an area approximately 78.5 square kilometers inhabited by nearly 1,10,000 people and 65,000 domesticated animals and birds. The agriculture, materials and structures of the area are also affected.
(3) Approximately 50 per cent of the households in the affected area have members suffering from one or more pollution induced diseases.
(4) Agriculture in the project area has become a gamble in the success of factory stacks and machineries engaged in industrial production and processing.
(5) It is economically feasible to protect the environmnt of the project area as incremental benefits exceed the incremental costs involved in the process.

### 9. Recommendations

(1) The attitude of the government relating to environmental problems must be one towards 'life and death' rather than 'law and order' problems.
(2) The official environmental protection agencies must be given executive powers to take action against the polluters.
(3) The enterprises must be compelled to spend some portion of their sales turn over for the prevention of pollution and the protection of the environment and
(4) The government should initiate various programmes to creat greater awareness of environmental problems among the public.

## S.S.e.10. RAMAKRISHNAN KORAKANDY–Technological change and the Development of the Primary Marine Fishing Industry of Kerala–A study of Limited Growth– 1988 – Dr. K.C. Sankaranarayanan.

### Introduction

The primary marine fishing industry of Kerala is one of the premier natural resource industries of the State which provides employment and earnings to a large section of the population. It is also a major foreign exchange earner to the state.

The marine fishing industry of Kerala has been given a pride of place in the five year plans of the state. But it seems that, after some initial expansion, the industry has failed to gather momentum. The output of the industry which reached the peak in the first half of the seventies dwindled thereafter. The declining trend in output has caused serious concern in all quarters connectedd with the industry. The present study is an attempt to unravel the process of growth and decline in the primary marine fishing industry of Kerala since 1951.

### Objectives

The specific objective of the study is to identify the factors that contributed to the growth of the primary marine fishing industry in the initial stages of development and the factors that led to its decline in the later stages. The study is limitedd to an analysis of the process of growth in the primary sector or the catching branch of the marine fishing industry.

### Hypothesis

The major hypothesis of the study is that the development achieved by the primary marine fishing industry of Kerala since 1951 is primarily the result of various technological changes that took place in the industry during this period. However, the development achieved by this industry during this period is limited.

### Methodology

The study is based on historical data.

### Scheme of the Study

For the purpose of analysis the thesis is divided into eight chapters. Chapter I presents a brief outline of the research problem, objectives and scope of the study. Chapter 2 makes a general review of the classical, neoclassical and current literature relating to the fishing industry. Chapter 3 discusses the conceptual framework and methodology. Chapter 4 gives an account of the traditional sector of the primary marine fishing industry of Kerala. Specifically it discusses the research and development efforts for fishery resources, fishing craft, fishing harbours, fishermen training etc.. Chapter 5 furnishes a detailed account of the various effects of the technological changes in the industry. Chapter 6 makes a detailed study of the 'indicators' of technological change and development in the primary marine fishing industry of the state. Chapter 7 discusses the characteristics and impact of technological change in the primary marine fishing industry of the state. Chapter 8 presents the conclusions of the study.

### Major findings

1. The output of the primary fishing industry of Kerala grew at an average annual compound rate of 2.08% during 1950-75 and 0.62% during 1976-1984.
2. The observed growth in the output of the industry from 1950 to 1975 is associated with the major technological changes that took place in the industry.
3. A major characteristic of this growth is the relatively higher growth rate achieved in the output of the demersal (bottom living) and high priced varieties of fish.
4. A large part of the increase in the output of the industry during this period is due to the increase in the output of the mechanised sector.
5. The relative share of the non-mechanised (tranditional) sector in the total output of the industry has declined over the years and this decline has been primarily responsible for the decline in the total output of the industry after 1975.
6. The output of the northern districts of the state has declined significantly over the years.
7. The fall in the output of the non-mechanised sector is primarily because of the limited growth strategy' followed by the administration during the whole period and the poor market linkages that developed during this period.
8. Restoration of growth in the primary marine fishing industry of Kerala demands major and continuous technological changes in the catching, processing and marketing branches of the industry.

### 9. Suggestions of the researcher

1. The technology prevailing in the traditional sector should be upgraded to promote efficiency and to enhance production.
2. The performance of the mechanised sector should be improved through rationalisation.
3. The decline in the catches of the northern districts of the state should be prevented by providing the fishermen of those districts with necessary capital (fishing craft and gear) and knowhow.
4. The various schemes being implemented through the Kerala State Cooperative Federation for Fisheries Development (Matsyafed) should be geared to achieve the targets for marine fish production in the state. Each primary society should be assigned a certain target for fish production each year.
5. Exploitation of the fishery resources of the exclusive economic zone of India, adjacent to the state should be intensified by developing the deep-sea fishing fleet of Kerala.
6. Fishing harbour/landing facilities should be provided for all types of vessels operating in the state. These facilities should be evenly distributed along the coastline of Kerala to avoid regional concentration of landings and for fair distribution of benefits to all regions.
7. The domestic and national market for marine fish should be developed to provide proper market linkages for development.
8. Development of fisheries should be recognised as teh chief objective of (fisheries) management. Fisheries Administration in the state should take special care to see that the plan-objectives are fulfilled in time under all circumstances.
9. Conservation measurs should be inlaid in the development plans to work as an automatic break to regulate the speed and direction of development.
10. The Department of Fisheries should collect or arrange to collect in cooperation with the Central Marine Fisheries Research Institute, regular statistics of catch and effort, costs and earnings and other economic data of mechanised and non-mechanised vessels using different craft-gear combinations in the state. This is important for technology assessment and planning.

## S.S.e.11. MEERA BAI, M.–An Economic Evaluation of Industrial Estates in Kerala–1988–Dr. K.C. Sankaranarayanan

### Introduction

After the Second World War several new institutional techniques have been adopted in promoting and guiding industrialisation. Of these institutional techniques, the technique of industrial estates occupies an important place.

The philosophy of industrial estates programme rests primarily on two major premises, namely, (i) economies of scale, and (ii) economies of agglomeration.

The industrial estates programme was launched in India in 1955. This technique of industrialisation was recommended in India by the Small Scale Industries Board. The responsibility regarding the implementation of the programme was entrusted with the State governments. The study under consideration is an attempt to make an economic evaluation of the industrial estates programme in Kerala.

### Objectives of the Study

The objectives of the study are:

(i) to make an assessment of the programme with regard to the realisation of the objectives of the industrial estates.

(ii) to examine the industrial efficiency and economic viability of small scale industries in the estates, and

(iii) to study the current problems of the small scale industries in the estates.

### Methodology

Data for the study were collected from all the 17 major industrial estates working in the state on the basis of a structured schedule. There wre 118 units in these estates.

The programme is assessed in this study with respect to

(i) promotion of small scale industries
(ii) generation of employment
(iii) development of entrepreneurship
(iv) extent of the utilisation of the local resources, and
(v) generation of income.

The relative performance of the industrial estates are evaluated by estimating and comparing economic efficiency indicators of the estates such as capacity utilisation, input-output ratio, rate of investible surplus, labour-capital ratio, etc.

### Plan of the thesis

The thesis is divided into eight chapters. The first chapter introduces the subject. It explains the background, philosophy and objectives of industrial estates progamme. The second chapter presents the hypotheses, methodology and a review of literature on the subject.

The third chapter deals with the Industrial Estates Programme in India with special reference to Kerala. The fourth chapter highlights the infra-structural facilities available in the industrial estates in Kerala. The fifth chapter explains the profile of the structure of industrial units. The performance of the industrial estates programme in Kerala is evaluated in the sixth chapter. In the seventh chapter the problems of the units relating to the supply of raw materials, power, marketing, labour, finance, technical and managerial aspects are studied in detail. Chapter eight presents the conclusions of the study.

### Summary and Conclusions

Industrial estate is a sort of permanent settlement for small industries. The objectives of the programme can be broadly divided into two-primary objective and secondary objective. The primary objective is industrialisation through the development of small scale enterprises. The secondary objective is industrial dispersal and regional economic growth. Operational and economic efficiency of the enterprises are also studied. The study reveals that the primary objective viz. industrialisation through the development of small scale industries has been partially achieved. This inference is based on the fact that industrial estates have helped in creating new small scale enterprises. But the fact that most of enterprises which joined the estate at the initial period stopped, functioning within a short time indicate the seriousness of the problem the industrial estates programme face. The product mix in the estates is not of the ideal type. Emergence of the techno entrepreneurs has helped to improve the efficiency of the small scale industries to some extent.

Judging the performance of the estates based on the secondary objective that is regional growth, the industrial units have utilised local labour and private savings.

Based on industrial efficiency criterion (input-output ratio and the rate of investible surplus) except a few estates, all are working efficiently in general. But even in the case of successful units nearly the third of the capacity created remained unutilised.

### Recommendation

The industrial estates in Kerala have not been a great success. There are a lot yet to be attained. The state has all the potentialities what is needed is proper planning and guidance. The government should properly formulate and implement a developmental policy especially with regard to providing market intelligence and assistance for improving the quality of production to extend the market. Timely supply of raw materials, at reasoanable rate is to be ensured for the smooth working of the units. Also steps should be taken to see that all the units that are given accommodation the estates attention with regard to provision of infrastructure facilities is to be given to the rural estate to over come strial decentralisation and regional economic growth may become a reality. A careful economic analysis should be undertaken by the Government and the entrepreneurs before starting production.

## S.S.e.12. AJOY MATHEW–A study of the Coconut Economy of Kerala, 1956–1983; 1988–Dr. K.C. Sankaranarayanan.

### Introduction

India is the third largest producer of coconuts. She accounts for nearly 16 per cent of the world production. Coconut culture and industry provide full or part-time employment to over 10 million people in India and contribute about Rs. 6000 million worth of agricultural and industrial goods. Coconut is essentially a crop of the small holder. The average size of the coconut holding in India is as small as 0.20 hectares.

Kerala is the leading state with reference to area and production of coconut among the various states in the Indian Union. The economic strength and weakness of the state, to a considerable extent, depend upon the strength and weakness of the coconut economy. Hence an understanding of the trends in growth in area, production, productivity, market structure, etc. in the case of coconut is of great importance in formulating policy measures with a view to strengthen the economy of Kerala. Hence the significance of the study.

### Objectives of the study

The objectives of the study are the following:

(1) to analyse the area, production and productivity of coconut cultivation in Kerala and to identify the relative importance of area and productivity in production and the factors that influence these parameters,
(2) to assess the changes in cost of production and profitability of coconut cultivation,
(3) to estimate the marketed surplus of coconut for each category of farmers, viz., large, medium, small and tiny, and
4. to study the economics of coconut prices and marketing of coconuts.

### Methodology.

Both primary and secondary data are used for the study. Primary data were collected using structured schedules. Kottayam and Alleppey districts were selected for the field survey. Two hundred farm households from four panchayats - two each from Alleppey and Kottayam districts were surveyed for detailed analysis.

### Scheme of the study

For the purpose of analysis the thesis is divided into seven chapters. In the introductory chapter the importance of coconut cultivation to the economy of Kerala state is highlighted. The second and third chapters contain analysis of changes in area, production and productivity of coconut cultivation in the state. The use of modern agricultural practices by coconut farmers is analysed in chapter four. The fifth and sixth chapters cover analysis of cost of production and profitability and diseases affecting coconut. The last chapter presents the summary and findings of the study.

**Findings of the study**

Analysis of data relating to area under coconut over the years clearly shows an increasing trend during 1955-56 to 1982-83 except in the years 1975-76 to 1979-80. The most substantial increase took place in the period 1965-66 to 1969-70 when the area under coconut increased by 20.3 per cent. The increase in area was due to conversion of paddy lands into coconut gardens against the backdrop of higher profitability of coconut.

Coconut had a clear price advantage during the 1960s. But during the 1970s this price advantage was lost to other crops such as cashewnut and rubber. However, substantial areas under different annual crops were converted into coconut gardens.

Analysis of trends in district-wise area under coconut shows that there was decline in area in four out of eleven districts. Quilon and Cannanore witnessed faster growth rates compared to other districts. On the other hand, Alleppey and Kottayam districts registered negative growth rate in area; these are incidentally the districts which are intensely affected by root-wilt disease.

The trend in yield during the period 1955-56 to 1982-83 has been analysed by breaking the period into five year sub-periods. These sub-periods have been analysed by studying the data for average cumulative percentage variations, absolute percentage variations and by fitting linear equations of the form $y = a + bx$. From our analysis it is seen that yield has been declining continuously till 1979-80. It was only during 1980-81 to 1982-83 that we see a surprising increase in yield.

The causes for decline in productivity has to be explained with reference to several factors. Important among them are the rainfed nature of coconut culture and the prevelance of root-wilt disease.

Studies on the effect of irrigation on coconut production reveal that poor yielding coconut palms (below 20 nuts per year) respond significantly to summer irrigation; they are found to increase their post-irrigation yield by more than 210 per cent. Coconut palms which are low yielders (20-40 nuts per year) show increase in their post-irrigation yield by about 130 per cent. Considering that the average yield in Kerala now is in the poor and low yield categories, it can be concluded that summer irrigation would benefit production of coconut to a considerable extent.

The Government of India's policy of import of copra and coconut oil has seriously affected the coconut cultivators of Kerala.

Kerala is slowly, but steadily, losing the prime position it enjoyed as the leading coconut producing state in the country. The monopoly it has in coconut is being challenged by states such as Tamil Nadu and Karnataka which are contributing their might in terms of increasing area and production.

There have been occasions when coconut trees were cut under the pretext of an "unremunerative" crop to give way to more "profitable" crops such as rubber and cocoa. This was a feature in the southern pockets of the state. The farmers did this in the background of low prices during 1982 when other edible oils like groundnut were recording higher levels of prices.

Coconut farmers are realing under the grip of middlemen who control and monopolise the market scene with the result that a reasonable price is denied to the farmers for their produce. Uneconomic prices and unsteady market, because of multinationals and monopoly procurers, are playing havoc with the livelihood of the average coconut farmer. The conditions of coconut farmers have been aggregated by the inability of our science and technology institutions to find a remedy for a killer disease such as rod-wilt despite years of extensive research.

An analysis of the trends in production in various districts of Kerala shows that, out of the eleven districts, six have witnessed decline in coconut production. The decline in production was quite sharp in Alleppey district. Of the remaining five districts, which showed an increasing trend, Ernakulam had the biggest increase. For analysing the trend three measures were used: average cumulative percentage variation, absolute percentage variation and the values obtained by fitting a linear trend equation of the form $y = a + bx$. Till 1969–70 the rate of increase in production was faster than that in the subsequent periods. Since 1970–71 the rate of change in production has been negative, with an improvement only after 1980–81

Data relating to changes in production were decomposed into yield effect, area effect and interaction effect for the period 1955–56 through 1982–83 using the following formula

$$P = A_1 xy + Y_1 x A + y x A$$

where P is change in production (between $t_1$ and $t_n$), $A_1$ is initial area (in $t_1$), A is change in area (between $t_1$ and $t_n$ $y_1$ is intial yield (in $t_1$) and y is change in yield (between $t_1$ and $t_n$). Our analysis shows that the yield effect or contribution of yield to change in production has been negative throughout the period except in the last period 1980–81 to 1982–83. It was mainly the increase in the area which contributed to increase in production till 1969–70 and which continued to have a positive contribution even during the period 1970–71 to 1974–75.

With better farming practices, which require ploughing, digging basins and applying adequate quantities of fertilizers, the total returns of coconut gardens in general, and those of small farmers in particular, can be increased. But the additional cost involved is often beyond the capacity of small farmers. Further, the existence of certain cultivation practices such as over crowding of palms in small plots of land have their own rationale so far as small cultivators are concerned. It appears that plots with density of cultivation above that prescribed by scientists as optimum, give larger net income.

Research findings that D X T and T X D hybrids start yielding earlier than the local variety and that they can be planted much closer than the local variety, thus increasing income per plot. But the practical experience of farmers shows that the hybrids are high risk varieties. They are more prone to failure in establishing into grown-up palms than the local varieties and require intense care, without which they would have problems in bearing and growth. Moreover, the hybrids have a major disadvantage in the short life-span it has, which is a major disincentive to the farmers.

The argument that the inverse relation between size and productivity is due to the impact of irrigation was examined in the present study. For this purpose, sample coconut gardens which had irrigation were seperated from those which were unirrigated. The productivity of unirrigated holdings was examined and the correlation co-efficient between size of the holdings and productivity in such cases worked out. This worked out to –0.234. The result shows that a weak negative correlation exists between size and productivity without the effect of irrigation. Thus, it can be concluded that the existence of the inverse relationship, as seen in the case of coconut, is not due to irrigation.

In order to study the relationship between size of coconut farms and per capita output values we fitted a simple linear regression and got the correlation co-efficient of 0.64. This value, which is positive and above moderate, shows that per capita output increases moderately with increase in size of coconut holdings.

Primary data collected through field survey shows that, according to the farmers who were given multiple choices, the main reasons for decline in yield of coconut were: (i) disease (94.35 per cent) (ii) declining quality of soil (55.37 per cent); (iii) rise in input prices (23.73 per cent); and (iv) ageing of palms (23.73 per cent).

The present study has thrown up data regarding the relationship between size of coconut farms and productivity. The findings show that holdings between 0–200 cents have the highest range of yield of 34–48 nuts while holdings between 201–500 cents have the next highest range of 29–31 nuts. While holdings between 501–600, 601–700, 701–800 cents give 23, 50, 19 nuts respectively, in the case of 901–1000 and more than 1000 cents respectively the yield is 31 and 19 nuts (Here the yield rate for holding size group 601–700 cannot be taken as representative as the number of cases in this group is not statistically significant). Thus, if we leave out the size-group 601–700, we see that yield has been coming down as the size of holdings increases. This reasoning may indicate a negative relationship between size and productivity. A more sophisticated approach of using regression analysis may be more acceptable. The correlation co-efficient size and productivity is –0.496 which is inverse and quite strong.

Some economists have opined that the inverse relationship is due to differences in the quality of land. On the basis of the data collected from the field survey this hypothesis was analysed. We took value of land in rupees as a proxy for quality of land. The correlation co-efficient worked out to –0.264. This means that, though an inverse relation exists, it is not strong.

Some researchers have opined that analysis of only productivity per unit of land is inadequate. They argue that, instead, output per unit of labour should also be analysed in relation to size of holdings. We adopted this method and got a correlation co–efficient of 0.586. Thus, it is clear that productivity of labour is higher in bigger farms.

Profitability as a criterion of efficiency of coconut farms was considered in the present study. For most of the coconut farms, income from coconut sales is only a small portion of their net income; substantial portion of their produce is for domestic consumption. Size-wise comparison of average profit of sample cultivators shows a weak positive correlation, giving the value of 0.0631 which implies that there are no differences in profitability between various sizes of coconut holdings.

The distribution of households of various sizes according to profit range reveals quite interesting facts. For sizes below 200 cents profit per acre is below the range of Rs. 501–750. Incidentally, the size 101–200 cents shows 11 cases above Rs. 5000 per acre and, as expected, sizes above 600 cents have profitability above Rs. 5000 per acre. These findings are not unexpected as they are mainly large-size holdings which can high profits per acre as the size of their marketed surplus is larger.

The share of marketed nuts in total production was found to be about 79 per cent. The number of nuts marketed declined by more than 18 per cent between 1981 and 1983. Analysis of marketed surplus per acre in relation to size of the coconut gardens gave only a weak correlation co-efficient of 0.003. This implies that marketed surplus is uniformly distributed among different size-groups.

Most of the coconut farmers who were interviewed in the present study opined that modern practices have no advantage over traditional methods as far as their impact on profits was concerned.

Analysing the results of our field survey, it was found that 86 per cent of the respondents used the local variety for replanting. There were many reasons which they listed for using mainly the local variety. These included better establishing record of the local varieties their greater tolerance to disease and the adulteration of hybrid seedlings available. Moreover, the hybrid seedlings were found to be eratic bearers and tended to perform badly under lesser care.

The opinion of the sample respondents regarding the effect of mixed cropping of cocoa on the productivity of coconut was examined. Out of those who responded about the impact of cocoa on the productivity of coconut, only 7.69 per cent claimed that cocoa cultivation benefited coconut productivity, albeit indirectly, that is, through the benefit of manure given to cocoa which was also utilised by coconut. Over 67 percent of those for whom the question mattered opined that cocoa cultivation reduced coconut productivity and 24 per cent could not discern much change. This finding is quite important because certain scientists have been promoting the theory of nutrient contribution by certain intercrops.

Study of paid maintenance costs shows that holdings above sizes of 600 cents have a lower proportion of their total paid maintenance costs spent on soil improvement such as application of manure and tilling of soil. It is mainly the holdings in size groups 51–600 cents that do substantial expenditure on tilling and application of manures. For all holdings, cost of plucking was quite substantial ranging from 21 to 56 per cent of total paid maintenance cost. This is because plucking is a semi-skilled job and all planters require hiring in of climbers.

The field survey also revealed that, among cultivable crops, coconut was still the most profitable one. This is because other crops which are profitable such as rubber and coffee cannot be grown on coconut land. Competing crops such as tapioca, oil palms, yams, pepper, nutmeg ginger, banana, plantain etc do not offer better profits.

Primary data showed that the cost-return ratio was more favourable in the case of bigger farms. The co-efficient of correlation between size of farms and cost-return ratio was found to be 0.704. In the bigger farms cost is lower.

## S.S.e.13. PAULSON CHUNKAPURA–A Critical appraisal of the Techniques of Monetrary Control and the efficacy of Monetary Policy in India–1988–Dr. K.C. Shankaranarayanan

### Introduction

This study is a modest attempt to analyse systematically the techniques of monetary control and to find out their effectiveness in the Indian context. The formulation and execution of monetary policy requires a thorough understanding of the working of the monetary system and the instruments of monetary control. Hence, a major part of the present study is concerned with discussions of these concrete issues.

### Objectives of the Study

The basic objectives of the study are:

(i) to examine critically the existing instruments of monetary control and the efficacy of monetary policy in India during 1970-85 period;

(ii) to assess the role of monetary policy in achieving the objective of price stability in India;

(iii) to provide some insight into the complicated problems of monetary management;

(iv) to focus light on the constraints and limitations under which the monetary policy of the RBI has to work at present;

(v) to study and analyse the new trends of monetary management introduced by the RBI during the recent years;

(vi) to explore how the RBI is drifting steadily from its orthodoxies to bolder policies of monetary administration in order to suit the structural requirements of a planned economy like that of India; and

(vii) to suggest some alternative measures for reforming and reorganising the monetary policy in order to suit the Indian condition.

### Hypotheses:

The present study proposes to test the following hypotheses:

(i) The efficiency of the instruments of monetary policy are rather limited in a country like India where both public and private sectors co-exist.

(ii) Administered prices are directly responsible for price increase in India rather than monetary factors.

(iii) A major cause of the substantial growth in money supply and inflation since 1970 has been the rise in the RBI credit to Government.

(iv) There must be proper integration of fiscal and monetary policies to control inflation.

### Methodology:

The data for the study are collected from secondary sources. The major source of data is the Reserve Bank itself—the monthly bulletins published by the RBI, the Reports of various Committees, occassional papers, Annual Reports on Currency and Finance etc. They are supplemented from other sources such as the planning commission, Central Statistical Organisation, the Reports of the Committees appointed by the Government of India, Ministry of Finance, International Monetary Fund and World Bank, authoritative books and journals, Research reports of individual scholars etc.

### Plan of the Study

For the purpose of analysis the study is divided into two parts. The first part comprises of three chapters. They discuss the theory relating to monetary policy and the important tools and techniques used to achieve the aims of monetary policy. Various aspects of monetary policy like basic notions, theoretical framework and its implications, objectives, importance and limitations of monetary policy are explained.

The second part includes four chapters which deal with the Indian experience. Attempts are made to evaluate the use and efficacy of monetary control techniques in India in attaining the goal of price stability during the past one and half decades.

### Conclusions and Recommendations

1. The findings of the study proves the hypotheses of the study.
2. The strong inflationary pressures witnessed in the Seventies and early Eighties have focused attention on the urgent need to pursue developmental strategies in a frame-work of price stability. Hence, price stability should be the foremost objective of monetary policy in India.
3. The single most important factor influencing the conduct of monetary policy in India since 1970 is the remarkable increase in reserve money.
4. The system of administered prices is mostly responsible for 'cost push inflation'.
5. The monetary policy and measures have failed to deal effectively with the price situation due to its own constraints and targeted flow of credit to the priority sectors and net credit to the Government creating reserve money.
6. The fiscal policy measures in most of the years since 1970 has not been conducive to the effectiveness of monetary policy. In fact, the fiscal policy has been an important factor in increasing prices. Similarly, the repeated fiscal action of marking-up of the administered prices for the purpose of raising revenue has materially contributed to the inflationary pressures in the economy. Moreover, the management of Government finances has reduced the effectiveness of monetary policy.
7. During 1974-76 period when drastic monetary control measures were the need of the hour both the Reserve Bank and the Government have closely co-ordinated their actions and have thereby achieved the desired results. Instances of such co-ordination have demonstrated the powerful impact of such concerted action by the Reserve Bank and the Government and serve to stress the importance of close consultation between them. Hence, what is needed is a cordial and symbiotic relationship between monetary policy and fiscal policy, in which the monetary policy performs its tasks as an equal partner and not as subordinator, and there is continuous coordination, integration, concommittance, and compatibility betwen the two policies so that their functioning becomes mutually rebounding. For a proper blending betwen the two, fiscal policy should aim at providing a background in which monetary policy can actively operate. This kind of co-ordination will make the goal of price stability feasible and possible. However, it is upto the Government to make such a relationship a reality.

8. A close coordination and proper combination of monetary and fiscal policies can be made through 'monetary budget' which has a specific aim of holding growth of money supply to a level consistant wih price stability.

9. The present policy of 'administering' interest rates should be discarded, and inteest rates must be raised to a much higher level.
10. The regulation of reserve money and money supply should be undertaken in a framework of monetary targeting in terms of a range, with feedback and with necessary support from an appropriate interest rate policy, which in turn can help in restraining the uncontrolled flow of money.
11. The techniques of monetary control should be used more frequently, more actively and more vigorously and there should be strict coordination between them for the purpose of economic stabilisation.
12. An important anti-inflationary factor in the long run can be an increase in production/output achieved through increased productivity and better technology in the economy.
13. Monetary policy needs reorientation and reform in a developing country like India because the RBI faces problems different from those in developed capitalist or socialist economies. The reorientation is also necessary because the importance of the monetary system has considerably increased in recent years and its spectrum is widening with a rapid growth of banking and non-banking financial intermediaries.
14. An important measure for redesigning our monetary policy would be indexing of money supply to the real growth rate of the economy.
15. An integrated monetary policy and planning will go a long way in improving the efficacy of monetary policy in India.

## S.S.e.14. THRESSIAMMA, K.V.–Movement of input and output prices of rice in Kerala and its impact on area, yield and output–1988–Dr. K.C. Sankaranarayanan.

### Statement of the Problem

The third world countries show an increasing trend of commercialisation of their agricultural sector. But the fact is that they do not produce enough food to meet their own requirements. This is true in the case of Kerala also. Available data indicate that area under rice in the state has been declining over the years both in absolute and relative terms. The declining trend in area under rice witnessed in recent years needs special investigation. The study tries to find out the reasons for the declining trend in area under rice in Kerala especially after 1974-75.

### Objectives of the Study

The specific objectives of the study are

(i) to analyse the trends in area, yield and total production of rice during the three seasons in the state, districts and taluks,

(ii) to study the trends in input and output prices on area, yield and total output of rice in the state, districts and selected taluks,

(iii) to estimate the impact of input and output prices on area, yield and total output of rice in the state, districts and selected taluks,

(iv) to examine conversion of paddy field, into coconut gardens and rubber plantations,

(v) to study the nature of price control and public distribution system in Kerala and to analyse the agricultural price policy of the Government in general

### Hypotheses

Input and output prices are important factors which influence farmers' decision to change area, productivity and production of paddy in the state.

The area under rice in the state has been progressively declining due to faster rise in wage rate, farm price of coconut and fertiliser price. There has been conversion of rice fields into coconut garden and coconut garden to rubber plantation.

The total production of rice in the state also has been declining mostly due to very rapid decline in area. Again, increase in productivity has been only marginal mainly because of lesser coverage under punja crop and high-yielding varieties of seeds, slow growth of irrigation facilities and paucity of fertiliser consumption.

### Methodology and Data Collection

The data for the study were collected primarily from secondary sources. For convenience, the period of the study is divided into three sub-periods, viz. (i) 1960-61 to 1968-69; (ii) 1960-61 to 1974-75 and (iii) 1974-75 to 1985-86. Again, the whole period is analysed under the title combined period.

Statistical techniques such as ratios, coefficient of variance, $R^2$ values, 'to' statistics, multiple regression etc. are used to analyse the various aspects of the problem pauced in the study.

### Scheme of the Study

The study is organised under seven chapters. The first chapter provides a brief introduction to the study. It also includes the statement of the problem, objectives, hypotheses, methodology and a brief review of the available literature on the subject. Chapter two discusses the cropping pattern in the state and the districts from 1960-61 to 1985-86. It also contains an analysis of the growth rates of area under coconut and rubber and the shift of acreage from rice to cash crops.

A discussion on the trends in growth rates of area, yield and output of rice in the state at different intervals forms the content of chapter three. Chapter four presents the trends and growth rates of input and output prices or rice and coconut at the state, district and taluk levels. The variables used in the multiple regression models is dealt with in chapter five. It also throws light on the supply response co-efficient obtained by applying multiple regression model to the data relation to rice crop.

Price control and public distribution system in Kerala, rationale of an agricultural price policy, critical estimate of the price policy and need of an integrated price policy are described in chapter six.

The concluding chapter, besides dealing with the summary of the study, highlights some of the policy implications emerging from the study.

## CONCLUSIONS EMRGING FROM THE STUDY

### 1. Changes in Cropping Pattern

The study clearly indicates the sift of land area in favour of plantation crops such as coffee, cardamom, rubber, cashewnut and banana and other plantations. Positive change in the yield of rice and tea was not sufficient to offset the decline in area and hence decline in production also.

### 2. Trends in Area, Yield and Total Production of Rice: Third Period

2.1. All the districts and the state have positive growth rates with reference to yield and negative grwoth rates with reference to area and production. Quilon and Ernakulam are exceptions with regard to production.

2.2. While all the districts and the state are having positive growth rates of yield, 13 taluks are having negative growth rates of yield.

2.3. Seventeen taluks are having positive growth rates of production, whereas only two districts are having positive growth rates of production.

2.4. While all the districts and the state indicate only negative growth rates of area, nine taluks show positive growth rates of area.

2.5. Seven taluks are having positive growth rates of area, yield and production.

2.6. Ten taluks have negative growth rates of area, yield and output.

2.7. Fortysix out of 57 taluks have less than two per cent growth rate of output and yield.

2.8. Of the 57 taluks, 31 have yield above state average.

2.9. Yield level of rice is higher in South Kerala compared to North Kerala.

2.10. Twelve taluks have positive growth rates with reference to area, whereas all the districts and the state have negative growth rates of area during winter season.

2.11. Quilon, Kottayam and Palghat districts have positive growth rates of area, production and yield under high-yielding varieties of rice.

2.12. All the districts and the state as a whole except Trivandrum have positive growth rates of yield under high-yielding and local varieties of rice.

### 3. Trends in Input and Output Prices of Rice

3.1. The general trend in coconut price is a continuous rise from 1960-61 to 1985-86.

3.2. Among the districts the Northern districts of Cannanore, Kozhikode and palghat show the maxmum increase in coconut prices followed by Ernakulam and Trichur in the various periods.

3.3. The relative price of rice to coconut moved in favour of rice till 1967-68 and then moved in favour of coconut. This resulted in increases in rice area until 1967-68 as the relative price moved in favour of it, but then began to stagnate and started falling after 1975-76 as the relative price began to move in favour of coconut after 1967-68.

3.4. In the case of coconut price increased steadily almost throughout the period from 1960-61 to 1985-86. But the relative price of coconut fluctuated erratically, which indicated that rice is not the only substitute for coconut. The consistent rise in coconut prices led to the bouyancy of coconut cultivation and the area under coconut increased continuously until 1975-76. Thereafter the trend changed in favour of rubber, coffee, cardamom cashewnu and banana and other plantains.

3.5. The compound growth rate of the variables can be ranked first as wage rate, then farm price of coconut, third fertiliser price and last farm price of padddy. Farm price of paddy was much lower than the growth rate of the other three variables.

3.6. The profitability of paddy reduced further after 1974-75 because of the steep rise in the wage rate, fertiliser price and comparatively low price of paddy.

### 4. Area, Yield and Production Response

4.1. Acreage responses are higher than boh the production and the yield responses.

4.2. Area, yield and production are more responsive to current year regressors than to previous year regressors.

4.3. Wage rate can be considered as the single and strong regressor in both the estimates, current year and previous year.

4.4. Twentyseven relationships out of 30 indicated negative response of acreage with wage rate, 22 with farm price of coconut and 20 with fertiliser price. But out of 30 relationships, 23 explained positive relationship between farm price of paddy and acreage. It is evident from the above description that high rate of wage, fertiliser price, coconut price and very low paddy price led to the decline in acreage under paddy during the third period.

4.5. The responsiveness of acreage to wage rate was negatively correlated during the third and the combined periods. This indicates the inverse relationship between acreage and wage rate.

4.6. The four regressors shared 52 to 97 per cent variation in acreage under paddy. The estimates were having very high value of 'F' ratio. Hence our conclusions regarding acreage response are highly reliable.

4.7. Only during combined period fertiliser price ranked first in the order of supply shifters in 't-1' estimates and the second one in 't' estimates. In all the other periods wage rate ranked first in the order of supply shifters. The main difference is because of more number of significant yield response related to fertliser price rather than acreage and production responses.

4.8. Yield has more impact on production than on acreage.

4.9. Coconut area has greater impact on paddy area than rubber area.

4.10. The second period indicates the highest acreage and production response when we take each regressor separately and calculate regression co-efficients, R values and value of 'F' ratios. It is clear from the above results that more positive responses of production and acreage can be seen upto the second period and yield response after the second period, ie, yield increased during the third period compared to the first and the second periods which may be due to the progression technological development. The results show the concentration of the highest area and production responses during the second period and yield responses during the third period.

## RECOMMENDATIONS

Whether Kerala should be self-sufficient in rice production is a matter for dabate. Yet the fact remains that we never reached the set targets of production in paddy in our plans. To reduce the gap between the internal requirement and the production of rice through effective planning and execution of programmes we should consider the following measures.

1. To increase the coverage of the high-yielding varieties in all seasons and to study the slow progress in this regard, a constraint analysis may be undertaken to throw light on policy issues to be tackled.
2. Irrigation facilities should be increased, so that more area can be brought under punja crop (summer.)
3. The variation in productivity in and between taluks in respect of all the crop seasons should be analysed and studied in order to raise productivity in areas where now it is relatively low.
4. The rate of growth of price of paddy is very low compared to the rate of growth of wage rate, price of coconut, price of fertiliser etc.. Hence to increase production of paddy, the price should be increased according to the rate of increase in other output and input prices over time.

There is another fundamental question of cost and price factors relating to the economics of rice production. We are in a blind 'fix' since the labour cost has been rising steeply the role of other factors, viz. land, capital and entrepreneurship and their remuneration have not received adequate attention in the discussion relating to cultivation costs. It is, therefore, necessary to re-examine the share of land, labour, capital and entrepreneurship in rice production.

Again, the present ad hoc agricultural price policy should be change to a well integrated policy, so that the problems related to price and cost factors can be avoided.

## S.S.e.15. LIZY, M.A.–Federal Financial Relations with Special Reference to Kerala–1989–Dr. K.C. Sankaranarayanan

### Introduction

In India as in other Federal Countries, States are endowed with less elastic sources of revenue while they have to perform a large number of functions. Cosequently all the states invaribly experience revenue gaps in their budgets. In the case of Kerala also such a trend is visible. Each State experiences problems of vertical fiscal imbalance differently owing to the presence of horizontal fiscal inbalances which arise from varying levels of development, levels of fiscal need, fiscal potential and performance. Even though transfer of resources from the Centre to the States increased during the study period, the available data indicate that in the case of Kerala there is imbalance between fiscal requirements and resource availability. Problems of persistent poverty and unemployment along wih high literacy level and high density of population continue in the State without any serious challenge from any quarter.

### Importance of the Study

The appointment of the Commission on Centre-State relations (Sarkarla Commission) highlighted the problems in federal state relations in India. There is a large volume of literature on the federal financial relations in other federations. The literature on Indian federal financial relations is also quite sizeable. But there has been no major detailed study on the financial relations of Kerala with the Centre.

The transfer of resources from the Centre to the State of Kerala has attracted much academic attention. But this was limited to a specific aspect or to a particular agency of transfer. Likewise issues related to various aspects of development of the State have been studied, but none of them looked into the finances of the State and its relation with the Centre. The present study tries to fill this gap by examining the devolution of resources according to its form (viz. tax shares, grants and loans) through agencies like the Finance Commission, the Planning Commission and various ministeries and also by making an attempt to unveil the composition of State Finances and expenditure. The study is likely to have relevance to policy formulation.

### Objectives of the Study

1. To examine the nature of the financial plans (budgets) of the State of Kerala.
2. To study the composition and growth pattern of statutory transfer of financial resources from the Centre to the State.
3. To examine the trends, growth rate of plan grants, non-plan grants, shared taxes and loans.
4. To study the taxation and expenditure pattern in the State as also duties in relation to variables like income and transfer of resources from the Centre to the State.
5. To study the behaviour of intra state resources allocation.

### Methodology and Data Collection

This is a historical study evaluative in nature. The study analysed the trends in revenue and expenditure of the State Government during the period 1956-57 to 1984-85. The study is largely based on secondary data collected from the reports of the Finance Commission, Plannng Commissions, Reserve Bank of India Bulletin, Budgets of the State Government, Combined finances and revenue Accounts, Minutes of the National Development Council meetings.

### Limitations

This study is however subjected to some limitations. The major limitation is owing to the nature of the data. The study period is limited to 1956 - 1985. The study period is coterminous with the second five year plan and second Finance Commission to sixth five year plan and seventh Finance Commission. It has not been possible to compare the Kerala situation with all the other States in all the stages of study due to changes in number of States and non-availability of data.

### Plan of the Study

This study is divided into seven chapters. The first chapter is introductory in nature. It consists of the general characteristics of the State economy, statements of the objectives, methodology, limitations and a brief review of literature.

The second chapter reviews the annual budgets of the State of Kerala for a period of 28 years with a view to understand the nature of the financial plans over the period.

The composition of statutory transfer of resources from the Centre to the State and also the adequacy of financial transfer was analysed in terms of variables which are more relevant to the State of Kerala.

The fourth chapter deals with trends of growth rates of plan grants, non-plan grants, loans, shared taxes from the Centre to the State.

Chapter five focuses on State taxes, duties and expenditure and the relationship between per capita transfer of resources from the Centre to the State etc.

The sixth chapter is an endeavour to analyse the development of regions in Kerala and the nature of plan allocations to these regions.

Summary, Conclusion and prospects of the study are presented in the last chapter.

### Conclusions

1. Even though several variables were considered for transfering financial resources from the Centre to the States, it is observed that most of these variables do not represent the specific needs of the State of Kerala.
2. An analysis of State taxes and duties shows that State's taxation has registered perceptible structural shifts a shift from direct to indirect taxes.
3. A region-wise analysis of plan allocations in the State has been done. The analysis revealed that plan allocations do not favour the backward regions.
4. The study highlights the nature of the financial plans of the State of Kerala. It further revealed that shortfall in Kerala's total revenue during the period under study was not exclusively due to the fall in Central transfers. It was partly due to the fall in State's own revenue.

### Recommendations

For having healthy financial relations between the Centre and the States the following aspects may be considered.

For selecting criteria for resource transfer, variables should be selected in such a manner that the selected variables should not have high correlation between each other but should represent the specific needs of the State.

The lion's share of the State's non-developmental expenditure is incurred for paying Interest charges. The Centre should not charge interest on the loans given to the State Government. Though it is not analysed, it seems relevant in the case of Centre-State relations.

For the efficient devolution of financial resources from the Centre to the States, either the uniform application of selected variables through different agencies or the setting up of permanent agency is the need of the hour.

While determining the share of Central assistance to each State, the Centre has to take into consideration the impact of its own policy regarding pay revision, granting of additional dearness allowance, salary etc.

The devolution of financial transfers in the constitution is based on the 1935 Act. Unless the constitution is changed stock, lock and barrel the prest discrepancy will continue.

### Contribution of the Researcher

Issues relating to various aspects of the developments of the State have been studied by various agencies and individuals. But none of them looked into the financial relations of the State of Kerala with the Centre. This study is an attempt to fill this gap by examinining the devolution of resources from the Centre to the State. It endeavours to unfold the issues involved in the problems referred, and urges the planners and policy makers to think on the lines suggested in order that a healthy relationship may result between the Centre and States in the matter of financial relation.

## S.S.e.16. ABRAHAM, P.K.–Model for developing rubber based industries in Kerala–1989–Dr. K.C. Sankaranarayanan

### Statement of the Problem

Kerala is producing over 90 per cent of Natural Rubber of India, a versatile Industrial Raw Material, used for producing over 50,000 consumer and Industrial products. Kerala has a highly educated, reasonably skilled and talented man-power. There is adequate development of Industrial infrastructure such as roads, railways, ports and communication links. Power, a major input for most of the rubber based industries, was surplus till recently. It was estimated that over the last one decade, there was an inflow of over Rs. 10,000 crore by way of foreign exchange remittance to Kerala.There is a huge consumer market making Kerala a continuous urban and semi urban agglomeration of people. The unemployment has crossed 30 lakh mark. Despite these favourable factors only around 10 per cent of Natural Rubber (NR) produced in Kerala is used as an industrial raw material inside the state. The balance is taken out as an industrial raw material for factories situated as far as Calcutta, in Bengal and Modi Nager in U.P. Due to this, the state is loosing a vital economic opportunity in terms of value addition; employment generation and market exploitation.

### Objective of the Study

The objective of the present study is to conduct an enquiry into the cause of non-development of Natural Rubber based industries in the State of Kerala, and to suggest a model for the industrial utilisation of a desired level of this raw material in the State itself under a time span.

### The Hypothesis

The hypothesis of the study is that lack of entrepreneurial, organisational and political leadership are the major causes of non-industrial utilisation of Natural Rubber in the state.

### Methodology and data Collection

Both primary and secondary data were collected, the University Library (Trivandrum), the Rubber Board and the Rubber Research Institute (Kottayam), the Centre for Development Studies (Trivandrum), the Trivandrum Public Library (Trivandrum), the State Planning Board (Trivandrum), the Bureau of Economics and Statistics (Trivandrum), the FACT's documentation Centre (Alwaye), the State Industries Department (Trivandrum), the KSIDC (Trivandrum), the KITCO (Ernakulam) etc were visited for collecting secondary data and surveying the available literature connected with the subject.

The secondary data were supplemented by a survey covering over 150 industrial units of which 80 per cent were rubber based. The selection of the units was done at random. A pre-tested questionnaire was used to collect data from them. Apart from answers for the pre-set questions, their views, opinions and judgements were sought on various aspects of industrialisation of the state. Leading entrepreneurs of the state were also met personally and their views ascertained to strengthen the validity of the conclusions.

### Limitations of the Study

Detailed feasibility and project studies on various rubber based units which can be established in Kerala could not be attempted in this study. Hence only certain broad and general recommendations could be made. Detailed feasibility and project report for model suggested will involve an expenditure of several lakhs.

### Plan of the Study

For the purpose of analysis the study is divided into 11 chapters. Annexures, tables and graphs that are relevant to the study are given at the end. A brief outline of each chapter is given below:

Chapter 1, viz. Historical background on the industrialisation of Kerala deals with the history of industrialisation of Kerala from early times.

Chapter 2 is on industrial Development during the Five Year plans in Kerala. This chapter deals with the Industrial development in the state after independence and during the successive Five Year Plans. It also compares Indusrial Development of Kerala with other States in India. The objective is to find as to where Kerala stands in the Industrial Map of India after 40 years of Planned Development.

Chapter 3 deals with the Industrial Backwardness of the State and the Employment situtation. It presents an overview of the economic situation of the State and elucidates as how the state has slipped in the Industrial field since independence and the consequent explosive unemployement situation in the state.

Chapter 4 presents the Scope of the Present Study. This explains also the background of the study, the problem, the scope, objectives, hypothesis, methodology and limitations.

Chapter 5 is on the History of Natural Rubber. This chapter summarises the history of Natural Rubber, its origin, development and present position in the world, India and Kerala as a plantation crop and as a major Industrial Raw Material.

Chapter 6 deals with both Natural Rubber and Synthetic Rubber. It explains, the invention of Synthetic Rubber and its substitution in the areas where Natural Rubber was ruling supreme. The composition of NR-SR utilisation in the world as well as in India over the years is also compared in this chapter.

Chapter 7 presents the Development of Rubber Based Industries with reference to the World Scene. This chapter deals with the various inventions which made rubber the most versatile industrial raw material. It traces the history of rubber based industries in the world. The consumption projection upto 2000 A.D. is also made in this chapter.

Chapter 8 explains the Development of Rubber Based Industries with reference to the Indian Scene. The development of rubber based industry in India and the estimated demand upto 2000 A.D. is also given in this chapter.

Chapter 9 is on Development of Rubber Based Industries with reference to the Kerala Scene. The history of rubber based industries in Kerala and its developments under various sectors are included in this chapter.

Chapter 10 discusses the reasons for Non-development of Industries in Kerala including Rubber based Industry. The stagnation of the Industrial Sector in Kerala, the reasons which led to the present situation, the unsatisfactory development of Natural Rubber based industry are dealt with here.

Chapter 11 presents the Conclusions and Recommendations Emerging from the Study. The study validates the hypothesis that lack of entrepreneurial, organisational and political leadership resulted in inadeuate investment and an unfavourable environment for the development of industries in general and Natural Rubber based Industry in particular. The labour image projected with reference to the state has driven away the outside entrepreneurs. It also compelled the native entrepreneurs to seek shelter in other states. There is no conscious move from any quarters to industrialise the state. On the other hand the anti-industrial lobby in the form of environmentalists and anti-pollusionists are most vociferous in the state. They successfully blocked the generation of additional power in the last decade which is the most important input for any industry. There was no worthwhile investment in industries in the state for the last 40 years in comparison with the states potential or need. The Government investment was mostly on education, health and social welfare activities and the private investment was on non-productive areas and conspicuous consumption. It was found that the State Frittered away over Rs. 10,000 crores remitted from abroad by the Gulf Malayalees during the last 15 years. The bureaucratic procedures have created road-blocks everywhere for entrepreneurs. The entrepreneur's social standing is very low compared to even a Clerk in Government. The Sales Tax and Excise Department consider an entrepreneur not as a respected citizen but a law breaker, account manipulator and tax evader. The political leadership which ruled Kerala over the past years never took up industrialisation as a major objective. The clear proof is the investment in this sector and the unbridled freedom given to labour to win their rights over the right of all others including the public. The organised labour with their militant practices created a fear psychosis among industriallsts which made Kerala out of bound for any entrepreneurial activity. The fate of a few industrialists like Birla (Mavoor), Dalmia (Punaloor), Binny (Cochin), Premier (Kalamassery) who ventured their investment in Kerala was enough proof for confirmation for others. While Kerala gave such negative and hostile signals to industrialists and prospective entrepreneurs, there were a large number of other states both near and far to give red carpeted welcome to them. The survey among the present entrepreneurs of the state has clearly underscored this. Rightly or wrongly, their preception is that other states like Tamil Nadu and Karnataka are mere condusive to start industries than Kerala. Many of them have established their second units in these States.

It was also found that Kerala has very little Native entrepreneurial class. The much celebrated "planter" is not an entreprenerur. He is only a big, better organised, well managed, scientific farmer. He faces less risk or uncertainly compared to an industrialist. After all his basic investment is in the land which is the safest one in the state. The next is in the traders and financiers who are after quick profits. While Kerala scared away the outside entrepreneurs it never produced or nurtured a native one, with the result that there was no one to give leadership in the field except the bureaucrats and Clerks in the Industries Department who in their little mind devised a web of controls to exert their power and authority. The attitude of Banks and Financing Institutions were not developmental. They took the traditional Bankers approach while lending for industries. They sanctioned loans in most cases only when they are covered.

several times by collateral security. Most of the banks who collected several thousand crores by way of foreign remittances from Kerala utilised it for lending to industries in other States. In fact the money remitted by Keralites from abroad were used for industrialisation of other States like Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra and Gujarat. The cumulative result of all these was the industrial stagnation of the State including the Natural Rubber based industrial sector.

### Recommendations

1. The major recommendation is the creation of an entrepreneurial class in the state as well as creation of an environment wherein entrepreneurs from outside is attracted.
2. There should be a social movement from the present educated, unemplyed youth towards industrialisation of the state, for they have to gain everything from such a change. This force should overcome the present anti-industrialist lobby, the environmental lobby, the pollusion lobby, and the militant labour lobby.
3. There should be an institutuon
   -- A Rubber Industries Development Corporation.
   -- In the Model of KELTRON to develop Natural Rubber based Industries in the State. This institution will have to concentrate on R & D and hightech and high capital projects. The low capital and low tech projects will have to be organised by selected and trained entrepreneurs on a franchaised basis in the rubber growing areas. Huge industrial estates in the rubber growing tracts have be developed for setting up these industries.
4. Capital for the investment has to be raised through an innovative system of share participation cum guaranteed job basis. All employees in such units will have to be participants and must be prepared to abrogate their trade union rights by consent. Necessary legal protection will have to be ensured by the Government for such organisations.
5. While the manufacturing model will have to be as above (The Keltron Model) the Marketing has to be undertaken through a Central Marketing Organisation with Branches and Sales Depots all over India (The Bata Model).
6. The suggested model envisages an investment of Rs. 2000 crores over a period of 10 years starting from 1990. On a conservative estimate it will convert about 90 percent of Natural Rubber which is additionally targeted to produce in the state for the next 10 years. In other words instead of the present 15 per cent, the industrial utilisation of Natural Rubber in Kerala will have to be raised over 50 per cent of the states production by the turn of the century. This is expected to produce an additional employment of over 200,000 in the State.
7. Power being a major input for rubber based industry, the Government should double the present installed capacity for power during the next 10 years. This will be possible by starting all the mini and major Hydel projects *including Silent Valley*, besides installing Thermal and Atomic Units. Private Sector may also be encouraged to start power projects.

### Contribution of the Study

The report of the High Level Committee on Industry, Trade and Power in their recommendations suggested that "our approach to industrialisation should also be resource based. Ninetytwo per cent of the country's rubber is produced in Kerala, but most of the rubber based industrial units are situated outside Kerala. One of the sub-committees set up by the State Planning Board has examined the prospects of rubber based industry in Kerala. In its report the Committee recommended a more intensive study to ascertain the prospects of rubber based industry in Kerala and the programme for development of the industry for the next decade". Following this KITCO and KSIDC have drawn up a number of project profiles for prospective entrepreneurs, including NRIS. However the scope of these studies were confined to the limited purpose of identifying commercially viable rubber based projects. Apart from these attempts there was no detailed study on the prospects of rubber based industry in the state. The present study is an attempt to bridge this gap.

# Faculty of Social Science

## (Management Studies)

### S.S.m.1 HARIDASAN, V.–An enquiry into the management practices followed in rubber estates in India–1979–
### Dr. M.V. Pylee

The broad objective of the study is to find out the management practice followed in the rubber estates in India. Comparing the management practices followed in the estates belonging to Indian and non-Indian companies is also an objective. An attempt is made to find out the divergence between the Indian and non-Indian companies in regard to various practices and to identify and bring them into broader relief so that the strong points of each would be emulated by the other.

The management practices are examined in the light of well-established management principles and techniques adopted in business and industry. Besides the widely accepted principle of management, viz., planning, organising, staffing, directing and controlling, other management principles and techniques relating to personnal, finance, marketing, materials and transporting are also examined in the appropriate context.

### S.S.m.2.JOS, C.A.–Problems and prospects of India's major spice - pepper–1979–Dr. M.V. Pylee

This study is directed to examine how far price fluctuations in pepper can be controlled in the Indian context so as to have reasonable and stable income for the primary producers which will ensure on adequate encouragement for higher production and better export earnings.

The study points out that the level of pepper prices has not been stable, even though the fluctuations are mild in some years. The high degree of variation in the prices introduces an element of risk and indecision as it upsets the pattern of consistent growth in the production of pepper. Therefore, the stabilisation of prices of pepper both at home and at international level is a necessity. It has been suggested that the producing countries through the pepper community should work for a long term stabilisation of price in the world market.

Variable export duties should form an integral part of a national price stabilisation scheme. Fixation of minium price, creation of stabilisation fund, or buffer-stock policy may hardly achieve the objective of stabilising prices of pepper. It has been further suggested that after ascertaining in a systematic and scientific manner the price which is fair both to the producers at home and the consumers abroad by the Spices Board, the State may make necessary adjustments, from time to time, in the tax structure so as to have a stable, reliable and an economic price for the producers.

## S.S.m.3. MATHEWS, K.C.–Materials Management Practices in Major Public Sector Undertakings in India–1979–Dr. M.V. Pylee.

This study has been made to examine the Materials Management Practices in Major Public Sector Undertakings in India in relation to the practices prevailing in other sectors of industries in India and abroad with a view to proposing suitable recommendations wherever necessary to gain optimum results.

A representative field had been selected from various categories of industries primarily depending on their investments and also considering the type of industry such as steal plants, fertilisers, ship building, machine tools, precision instruments and watches. Twenty such companies each from the public and private sectors have been selected for this study along with twenty foreign firms with similar manufacturing activities.

The need for monitoring information in materials management types of information systems, its processing and training in the use of systems are some of the areas discussed and after comparing these to the existing practice followed in the industrial organisation surveyed, conclusions have been reached.

Suggested recommendations include:

1. Planning required for quality materials in economic quantities at the right time to avoid stock outs and additional cost.
2. Lead time to be improved through proper delegation, responsibility, authority and accountability of the materials personnel.
3. Inventory levels to be brought down by the use of modern techniques of selective control on value basis, economic order quantity, standardisation etc.
4. To step up import substitution efforts through the development of ancilliaries and small scale industries.

## S.S.m.4. JOSE THOMAS–The Economics of Rubber Plantation Industry in Kerala–1979–Dr. K.C. Sankaranarayanan

The thesis brings together valuable historical and current information from different sources to describe the state of affairs in the rubber plantation sector from the economic stand-point. It brings out graphically the difference between the estates and holdings in such vital matters having a direct bearing on profitability such as production costs, price and marketing facilities. The study covers a period of 25 years from 1950-51 to 1974–75

**Methodology:** Data for the study were collected from secondary sources. The break-even technique is used to analyse profitability.

For the purpose of analysis the thesis is divided into eight chapters.

**Conclusion:** The economic position of the small holdings are weak. There is lot of scope in improving productivity in the plantation sector and thereby increase profits. The practice followed in Malaya regarding tapping if followed, will help to increase productivity.

## S.S.m.5. NAMBOODIRIPAD, P.V.S.–Investment Analysis of Chemical Projects and Development of Standardised Mathematical Co-relation for Cost Estimation of Pressure Vessels in Chemical Industry–1980–Dr. N. Parameswaran Nair

The project cost for industrial investment is generally estimated by the finance required for its various constituents such as know-how, land, buildings, equipment, etc. Of the above, equipment constitute a major portion. This is particularly so in the case of chemical industries. Among the equipments, a lion's share goes to pressure vessels. For estimating the cost of pressure vessels, most of the vendors and fabricators used at present their own conventional estimating practices. There is no stadardised procedure for the country as a whole to make this estimation, based on scientific methods of cost and investment analysis.

This study is concerned with developing and establishing a standardised procedure for the cost estimation of pressure vessels in chemical industries.

The problem of the study is to develop a technique of investment analysis for chemical projects. The study attempts to develop a standardised mathematical co-relation for cost estimation of pressure vessels in chemical industries. The methodology adopted is as follows:

1. Dimensional analysis is employed to analyse the dimensionless groups formed with all the influencing parameters by graphical method.
2. The validity of the above method is checked by employing multiple linear regression analysis.

A viable equation has thus been developed to get the estimated cost of the pressure vessels.

## S.S.m.6. WILSON, P.R–Financial Planning & Control in Public Sector Undertakings in Kerala–1982–Dr. N. Nanukuttan Nair

India is wedded to the ideals of socialism and democracy. Our country is undergoing a unique experience of planned economic development in a democratic set up. We are experimenting on a system of mixed economy for the speedy transformation of our semi-stagnant agro-based economy to a strong dynamic and industrially advanced one. In this growth oriented endeavour the public sector along with the private sector is playing a vital role.

The state of Kerala is industrially backward and so the government has started many industries in the public sector. Most of them being commercial enterprises are expected to make sizeable surplus and contribute to the meagre resources of the Government and for their further growth. But it is a sad fact that many of them had continuously incurred losses and even depleted their capital resources. In fact success or failure of all functional areas considerably depends upon the manner in which the finance function is executed and controlled.

So the major problems posed are:

How is financial manager in public sector performs his functions? What are the salient features of financial performance?

Are there proper financial planning and effective financial control in these organisations?

If they are practised, why are they not effective in controlling and improving financial performance?

The following are major hypothesis.

It is said that in all the public sector undertakings there is financial planning and control but is not pratised according to sound management principles.

Financial performance analysis is not systematically done to identify the strengths, weaknesses, opportunities of the firm and the threats faced by them.

Financial planning is done and control exercised at different levels of the organisation without proper integration and co-ordination.

The present study is both descriptive and analytical. Descriptive in the sense that it trace the historical growth and present performance and analytical in the sense that it interprets and analyses the data and also projects future trends.

The study is limited to the industrial undertakings in the public sector run by Kerala State. Out of the total 21 manufacturing units 18 units are covered. The study is particularly directed to financial performance concentrating on planning and on control of finance.

Major conclusions and recommendations are the following:

Many of the concerns are depending on borrowed capital for their existence Interest charges proved to be very heavy as compared to other expenses.

More than 50% of the units covered by the study are practically insolvent and they are made to exist by artificial respiration in the form of liberal loans from the governments.

External factors like ministerial intervention, multiunionism, trade union interference, political influence etc. have many a time proved to be stumbling blocks to the smooth functioning of the undertakings.

Appointment of inexperienced bureaucrats to top positions for short periods, lack of motivation and inventive systems are other major causes for inefficient functional performance.

Incompetency of non-professional managers in these undertakings is great drawback. Profits are made only in the concerns having a protected market. Those concerns producing goods competing with private sector are selling their products below the cost of production.

Decisions are made on the basis of experience. In many cases, they are unscientific and proved to be unsound.

In a few cases the reluctance to follow the trends of product life cycle have proved to be disastrous. In many undertakings lack of production control resulted in continued losses.

A number of concerns having surplus labour consider it as social responsibility to keep them. This inflates the labour cost and reduces the labour productivity.

Expansions and diversifications often end up in dead investments and financial crisis.

Decisions like location of industry, employee strength etc., should not be political decisions but should be on the basis of econimic vaibility and sound business principles.

Diversifications and expansions should be on the basis of proper market studies and realistic project reports and should be implemented and completed according to the schedule.

Work standards should be introduced in all the units. This can be made a part of bargaining at the time of long-term wage agreements.

## S.S.m.7. KRISHNAN NAMBOODIRI, P.N.-Motivation and Expectation Realization of Employees in Selected Industries in the Industrial Belt of Alwaye-1982-Dr. P.N. Narayanan Nair

This study employs a combination of field survey and mathematical correlation of data to measure the motivation and find out precisely what is expected by the employees and actually the extent of realization, that is to say the gap between expectation and realization.

The study shows that the level of expectation and realization of the employees in the select industries are above the motivator zone. In regard to their expectation they are in the closer vicinity of the ideal or innovator zone. In regard to their realization they are in the lower levels of innovator zone or in the upper levels of motivator zone.

The study suggests that the following improvements and reform are warranted:

i) Proper legislation is essential to effect internal leadership;

ii) workers participation in management should be implemented by incorporating the actual worker;

iii) labour department must be freed from political interference and influence; and

iv) trade unions should have no affiliation and affinity with any political parties.

## S.S.m. 8. GEORGE, K.K. - Centre-State Financial flows and Inter-State Disparities in India—1983—
Dr. N. Parameswaran Nair

In this study, the resarcher examines how far a set of regional policies aimed to regulate inter-regional transfer of financial resources, has been effective in achieving the objective of reducing the disparities in development. To prevent wide disparities among Indian States, the Indian federation has been moulded deliberately into a tighter one, even at the cost of States' autonomy, bestowing wide powers and vast resources upon the union. All the Five Year Plans had emphasised the objective of balanced regional development. The author observes that despite this objective, the powers and resources with the central Government and its agencies have been utilised in the opposite direction, accentuating regional disparities and consequently regional discontent.

The study assesses the divergence trends in the Indian economy and examines how and why the declared regional goals had been defeated by the different agencies like the Finance Commission, Planning Commission, Various Union Ministries and financial institutions.

The various chapters focus attention on the disparities in budgetary expenditure of different states, the aggregate budgetary transfers from the centre to different states during the various plan periods, the redistributive effects of statutory financial transfers effected under the aegis of different Finance Commissions, non-statutory non-plan transfers effected by the Planning Commission and the different Union Ministries according to their direction, the reverse flow of funds from the states to the centre in the form of repayment of loans and interest payments etc.

A detailed discussion is also available on the flow of institutional finance from leading financial institutions like commercial banks, development banks including

Life Insurance Corporation and Unit Trust of India.

The conclusion that emerges from this study is that all the agencies entrusted with this task of resource allocation – the Financial Commission, Planning Commission, Union Ministries and Financial institutions – have without exception failed to bring succour to the poorer state. All the major instruments of regional policy have failed to arrest the widening trend in regional disparities in India.

As solution to the problem of regional disparities, the author suggests an identification of the criteria of backwardness and also an identification of the backward areas. Inter-state disparities in income levels can be corrected only by reversing the present directions of the financial flow from the Union Government and the financial institutions. Instead of funds flowing from the backward to the developed states as at present, more funds should flow from the developed to the backward states.

## S.S.m. 9. MATHEW, P.V.–Materials Management in State Transport undertakings in India with special reference to Kerala State Road Transport Corporation–1983–
## Dr. N. Parameswaran Nair

This study examines, the prevailing set up, procedures and practices of materials management in the Kerala State Road Transport Corporation (KSRTC) and compares them with the prevailing practices in other similar state transport undertaking. It indicates several areas for improvement with respect to the organisation, materials planning, purchasing, stores-keeping and other aspects. It also seeks to develop a comprehensive inventory control for KSRTC.

A statistical analysis using certain key performance indicators of materials management has been attempted for KSRTC and other selected undertakings. The analysis covered 14 year period from 1965-66 to 1978-79 in respect of KSRTC and six year period from 1974-75 to 1979-80 for comparison among the sample undertakings. The consumption pattern, stock levels, stock movement, reordering and reviewing policies, lead time and other aspects of materials management in KSRTC were critically examined.

Major recommendations have been grouped under five areas—organisational set-up, materials planning, purchasing, stores-keeping and inventory control.

Several changes in the existing set-up and practices in KSRTC have been indicated and a new inventory control system has been developed with a view to improve the performance of the materials management function.

## S.S.m. 10. THARIAN GEORGE, K.–The Economics of Tea Plantations in South India–1983–Dr. Jose T. Payyappilly

The study is essentially focussed into the factors behind theso calledstagnancy in the tea prices, with a historical analysis of the development of tea plantations in South India from its inception to late 1970s.

In the first chapter the author explains the main features of the plantation system of agriculture, the factors behind the introduction of tea cultivation in India by the British and the subsequent development of it in South India.

The Chapter II deals with the structural changes leading to the capitalist development of tea plantations is.South India and its consequences. This section also includes the role played by the merchant capital (coast firms in South India) and the managing agencies for accelerating the capitalist development of tea plantations.

Chapter III is concerned with the pattern of tea production in South India, its differences with tea production in other areas, size-productivity relations, relationship with size of a tea estate and the age group of bushes, trends in area under tea etc.

Chapter IV contains an analysis of the evolution of the present day system of tea marketing with a clinical scrutiny of the factors behind the stability of tea prices compared to the trends in the prices of other planatation crops.

The evolution of small tea growers in South India, peculiarities of their production organisation and marketing and their problems are dealt with in Chapter V.

Chapter VI of the study is concerned with the labour in South Indian tea plantations. It analyses the peculiarities of plantation labour vis-a-vis the recent trends in employment, wages and the changes in their living conditions since independence.

Chapter VII analyses the developmental and financial problems of the Indian tea industry in particular. Chapter VIII summarises the main conclusions and the recommendations of the study.

## S.S.m. 11. JAYALAKSHMY, K.A.–Economic Impact of land reforms in Kerala–1983–Dr. K.C. Sankaranarayanan

Agrarian relations in Kerala was mainly based on the caste system. It was the ascendancy of the Brahmins (Namboodiries) which led to the feudalistic agrarian relations. Prof. Kunjan Pillai with the help of historical evidence holds the view that the Jenmi-Kudiyan system was the product of a peculiar socio-economic situation of the region. The Sangam period shows no evidence of a land owning Namboodiri class. On the contrary there are evidences to show that land belonged to the Kuravas, the Pulayas and others. With the Aryans' migration temples became the centres of learning and Brahmins were entrusted with the trusteeship. As managers of vast areas of fertile land, the power and influence of Brahmins increased. Various tenure rights suited to their interests were created. The British mistook the jenmi for a landlord of the European type. This upset the customary land relations.

The present study evaluates the economic impact of land reforms in Kerala. The study covers a period of 24 years i.e. from 1956 to 1980.

### Hypothesis of the Study

A satisfactory system of tenure is an essential condition for an efficient agricultural industry. The implementation of land reform measures helped to increase productivity and capital formation. It also led to a better social and cultural life.

### Methodology

The study is partly descriptive and partly empirical. Data for the study are collected from (1) Published government documents, (II) Survey conducted by the Bureau of Economics and Statistics (III) Land Board and (IV) N.S.S. data pertaining to land reform. The data collected from these sources were supplemented by a survey conducted in two villages.

**Scheme of the Study**

For the purpose of analysis the thesis is divided into two parts. The first part comprises of nine chapters. The first four chapters provide a sort of introduction to the main body of the thesis and provide the historical background to the land reform measures undertaken In Kerala. The next five chapters discuss the various aspects of the reform measures and their implementation. The second part comprises of three chapters. The first chapter in Part II discusses the economic impact of land reforms, the second chapter presents the results of the empirical study and the final chapter the conclusion of the study.

**Major Conclusions**

Reforms measures smashed the exploitative social order. The system of joint family was broken and consequently the social influence of jenmi was eroded.

Reforms have not completely succeeded in eradicating oral tenancies and benami ownerships. The register containing authentic particulars about land such as ownership and tenancy, rent and revenue are not updated. This has helped many large land owners to make benami transfer and to evade the ceiling provisions.

If the pressures on land remain unabated and productivity does not increase appreciably land reform will prove only a short-term palliative.

## S.S.M.12. SURESH, K.A.–The Economics of Cardamom Plantations in Kerala–1984–Dr. Jose T. Payyappilly

The study proves the hypothesis that production inefficiency exists in the resource utilisation of Cardamom plantations in Kerala during 1979-80.

With appopriate assumptions, precision of concepts, computational and sampling methods, the intermediate and integrated efficiencies of resource utilisation in the cardamom plantations of Kerala are explored in the present study.

The thesis contains five chapters. The first chapter *is introduction.* It explains the growth of cardamom plantations in Kerala, subject matter of the study, scope and significance of the problem of efficiency.

*Chapter II* has introduced a general theory of efficiency and *Chapter III*has analysed the conditions, determinants, criteria of evaluation etc. of various types of efficiencies in economics.

*Chapter IV* has revised the literature on efficiency and allied problems.

*Chapter V* contains the findings and suggestions.

According to the author, cardamom planters are found to be experiencing serious production problems, but still there exists remarkable potential of intermediate and integrated efficiencies in the cardamom plantations of Kerala, which implies that the material welfare of the specified plantation community can be enhanced by reorganising the given volume and conditions of resource utilisation.

The study also highlighted that great potentials of growth and welfare are prevailing in the field of study as proved by the existence of imperfect efficiencies in all the stages of resource use.

## S.S.M.13. CHANDRASEKHARAN PILLAI, N.–Recruitment and Training of Managers in the Public Sector concerns in Kerala–1984–Dr. N.Parameswaran Nair

The principal objective of the study was to investigate the salient features of the human resource development system that are available in the various public sector units in the State and to make significant comparison with practices prevailing in priviate enterprises, and in the governmental system. The specific objectives examined in the present study include the following: viz

1. manpower planning - policy and practices followed in public sector undertakings in Kerala.
2. the recruitment and selection methods and procedures.
3. the general aim of management training in public sector enterprises.
4. the systems of management training in the public sector enterprises with reference to its organisation and administration.
5. the management training system prevailing in the various public sector units and their adequacy to attain the goals laid down.

According to the present study the rationale behind the establishment of public enterprises is not just profit alone, but also the fulfilment of certain national objectives of economic and social transformation. It is necessary to develop a distinctive ethos or value system for the effective management of public enterprises. Indeed, the public enterprise managers should be stern custodians of public interest.

There is a certain lack of professionalism in managing public sector concerns in Kerala. Modern methods and style of management are also conspicuous by their absence. It is suggested in this study that all the public sector units have to attempt to define their objectives and set targets for future after consideration of their internal and external environment.

## S.S.M.14. RAJAN NAIR.–A Study of the Evolution and Working of Regulated Markets in Tamil Nadu–1984–
## Dr. N. Parameswaran Nair.

This study presents a detailed investigation of the origin and development of regulations in agricultural marketing in Tamil Nadu. It evaluates the method and process of regulation practised through the organisation of a chain of regulated markets in the State. The study also examines in detail the conceptual frame work behind state intervention and show the original concept has been modified subsequently to suit the changed conditions during the post-independence era of planning for economic development.

Specific objectives explained in the present study include the following: viz,

a) The historical aspects that necessitated state intervention in agricultural marketing in the form of organising regulated markets and their evolution.
b) The conceptual and organisational bases of regulated markets in Tamil Nadu.
c) The impact of such regulations on the existing trade channels or systems.

d) The performance and efficiency of regulated markets and their achievements.

The study also has suggested some remedial measures to reorganise the present organisational pattern of regulated marketing in Tamil Nadu.

## S.S.M.15. THANGAM JACOB–The Impact of Sterilisation on Family Relations–1984–Dr. C.M. George

Hypothesis tested in the study are the following:

a) Although sterilisation is projected officially as the ideal method for the illiterate masses of India, the people have not come to accept it as such.
b) Sterilisation as a method of birth precaution has not succeeded in making an impact upon people as the event that promotes happiness of parents and children.
c) The fear that sterilisation will permit extra-marital indulgences does exist among people and such fear will lead to loss of respectability for the method.
d) Couples who feel that their family lives have been affected adversely by sterilisation are those whose family lives have not been happy before the operation.
e) Well-adjusted couples undergo sterilisation without its affecting adversely their future family lives.
f) Sterilisation is resisted by people because it is a surgical procedure requiring hospitalisation.
g) Fear of child and infant mortality is an obstacle that stands in the way of early sterilisation by couple.
h) Psychological and religious barriers present serious hurdles in persuading couple to get sterilised.

The report is divided into six Chapters viz,

Chapter–I Introduction
Chapter–II Description of respondents
Chapter–III Motivational factors
Chapter–IV Relationship between spouses
Chapter–V Parent - child relations
Chapter–VI Summary, findings and conclusions.

The author's main finding that acceptance of family planning and its favourable outcome were pronounces in families where good inter familial relationships existed calls for a new approach to the entire Family Planning Programme that would give emphasis to favourable family relationships as a condition precedent to successful implementation of the Family Planning Programme.

## S.S.M.16. RAMASWAMY V.S.–A Study of the Marketing of Fertilizers in India–1984–Dr. N. Parameswaran Nair

The thesis starts with an overview of Indian agriculture and the Indian fertilizer industry and stretches on to various aspects of fertilizer marketing like the fertilizer marketing system in the country, fertilizer transportation, fertilizer warehousing, pricing of fertilizers, distribution channels, marketing costs.

This study which covers all the different types of chemical fertilizers that are marketed in India is an all India study. It covers all the major aspects of fertilizer marketing such as product-wise, logistics, distribution promotion, prices and subsidies and distribution margins and marketing costs. The main thrust of the study, however, is on the following core aspects of fertilizer marketing, namely, logistics, marketing costs and distribution margins.

The study also evaluates the various policies that have been enforced by the government from time to time on the marketing and distribution of fertilizers in the country.

## S.S.M.17. MARY JOSEPH–The Economics of Chemical Industry in Kerala–1984–Dr. K.C. Sankaranarayanan

The chemical industry occupies a significant position among the capital intensive large scale industries. Today the chemical industry produces a wide range of products such as inorganic and organic chemicals, fertilisers, petrochemicals, dyes, oils, fats, pesticides, drugs and pharmaceuticals etc.

In Kerala however the chemical industry had a very late start. Being a highly populated state, Kerala had hitherto gone in for labour intensive technologies.

### Objectives of the study

The main purpose of the study is to examine the growth and development problems of the chemical industry in the State of Kerala. Problems of productivity and efficiency with respect to the different sub groups of the industry are studied. A study of input-output linkages between the different chemical units is also studied. The chemical industry is generally characterised by high linkage effects. These linkages can be used to generate subsidiary industries and thereby help in the growth and diversification of the industry. The working of the individual units is also studied to understand the problems involved and to suggest remedial measures.

### Methodology

The study is partly descriptive and partly analytical. It is descriptive insofar as it traces the growth and development of the industry at the national and state level. It estimates the productivity of the factors involved and the efficiency of the working of enterprises. Secondary data as given in the Annual Survey of Industries was used for this purpose. To study the efficiency of the individual units in the chemical industry, a survey was conducted among the medium and large scale chemical units. Out of the fortyfive chemical units, fourteen were studied. The Cobb Douglas production function and the C.E.S. Production function are estimated to analyse problems of productivity efficiency. A partial input output table has been constructed to find out the interrelations between the units. Rasmussen's method of estimating linkages using the Leontief inverse are worked out.

The study leads to the following conclusions:

1 Labour productivity and capital intensity have shown increases in the different sub-groups of the industry. Capital intensity has increased much more than labour productivity. Large increases in capital intensity has not resulted in any substantial increase in capital productivity. Labour productivity is general seen to be higher than the wage rate in the chemical industry. This is probably the result of the highly capital intensive nature of the industry. Eventhough the wage rates are lower than the labour productivity indices, they are higher

than the wage rates for all manufacturing industries.

2. From the production function estimates, fixed capital coefficient appears significant in all the sub-groups. Labour coefficient does not appear significant except in the case of basic organic and inorganic chemicals.
3. For all the sub-groups elasticity of substitution is less than one which goes to show that capital labour substitution is generally not feasible in the chemical industry. This is a very big handicap for a labour abundant economy like Kerala.
4. The chemical industry is characterised by very high input-output linkages. These linkages are yet to be developed so far as the chemical industry in Kerala is concerned. Many of the units have good prospects for expansion and diversification. Many new projects can be started using the products/bye-products of the existing units.
5. As regards the working of the individual units the study has brought to light several interesting conclusions. With regard to the public sector units there has been a persistent trend of accumulating losses. Cost escalation of inputs is a very serious problem. The efficiency of input usage in many cases appears to be going down. Material standards of consumption are rarely adhered to. Lack of inventory control and production planning have resulted in heavy losses for many of the enterprises. Overtime payments are found to be very high in most of the public sector chemical units. Labour efficiency however does not come up to the desired levels. Heavy costs incurred on power and fuel, interest payments and depreciation charges have inflated costs. Capacity utilisation is very low in many of the units.
6. Pollution hazards are a serious threat to the quality of life in the economy. Pollution problems are on the increase especially in those areas where there is a concentration of chemical units.

## S.S.m. 18. DHARMA RAJAN, P.G.–A study of the cost structure of the Cashew Industry in Kerala, Karnataka and Tamil Nadu–1985–Prof. P.N. Rajendra Prasad

This study adopts a comprehensive framework of analysis compassing the major issues involved in marketing of cashew under the private and public sector, migration of the industry and the financial requirements of the industry. Cashew being an export oriented industry, the study is not limited to Kerala and other cashew producing states in India, but also extends to the major producing and consuming countries of the world.

According to the author, the imperative need of the time is the production of more cashew nuts within the country, which will not only provide income to the farmers who cultivate but also generate employment to the labourers who are employed in the processing units and gain valuable foreign exchange for the country.

The study highlights the need for a co-ordinated and balanced view of this commodity for its proper development and promotion.

## S.S.m. 19. BABY JACOB–A blue print for export development of Kerala–1985–Dr. K.C. Sankaranarayanan

Kerala has to its credit a glorious history of foreign trade stretching over many

centuries past. It had enjoyed virtual monopoly over the export of Spices, Cashew kernels, Seafood, Coir and Coir products. In the case of some of these items the monopolistic position has already been lost while in the case of others it is under threat. The migration of traditional export-oriented industries from Kerala to adjoining states should be a matter of deep concern. A major part of the cashew industry in the private sector has already moved from Quilon – the centre of the industry in Kerala – to Kanyakumari District in Tamil Nadu for reasons of lower processing cost and difference in wage rates. The seafood industry, due to declining fish landings and other factors, is also moving from the State's traditional bases. The Coir industry is in the grip of a grave crisis precipitated by unrealistic government policies and aggravated by a rapidly shrinking share in the International market.

The present study is done with a diagnostic perspective. Besides investigating into the causes of the stagnant situation, the study with its specific reference to agricultural exports attempts a critical review of the policies of the government and an evaluation of the programmes and performance of the various organisations entrusted with the responsibility of the development of respective agricultural commodities.

## S.S.m. 20. CELINE K. SCARIA–Wives' contribution to executive growth–1986–Dr. C.M. George

The second half of the twentieth century witnessed uprecedented efforts by women to enhance their satus and role in society all over the world. Declaration of the year 1975 as the International Year for Women by the United Nations is considered as an epoch-making event in the march of civilization. This is also considered as a recognition of women's roles mainly as the nerve centre of family welfare. Research studies on women carried out under different cultural contexts have identified a number of roles that are significant. But no scholar seems to have identified the role of the wives of business executives as a subject-matter worthy of deeper probe and understanding. They are in fact the pace setters in social change without being organised, or, being part of any organization as such, and without being aware of their influence. This tiny section of Indian womenhood has a profound influence on the rest. The purpose of this study was to find out the importance of wives' roles in the professional advancement of their husbands.

The objective of this study is to ascertain the impact of housewives's role in executive performance and growth. The details of this are spelt out in the hypothesis.

**Hypothesis for Verification:**

a) Higher the educational level of the wife, greater may be the professional upward mobility of the executive.
b) Higher the degree and quality of house management by the wife greater is the executive growth of the husband.
c) Higher the acceptance in the inter-personal relationship, greater is the upward mobility of the executive in his profession.
d) Higher the extra-professional activities of the wife, such as club-going, social gatherings and meetings with the wives of other executives, greater is the professional growth of the executive.

The findings of the study have been examined in the light of the basic assumptions of the study and it has been possible to make meaningful conclusions.

For the purpose of this study we had four hypotheses. We collected adequate data on a scientific basis on all the four hypotheses. On analysis, we have found that three among them have definite supportive data to prove their validity. In respect of the fourth, although the data on some respects support the hypothesis, it cannot be conclusively proved, as some factors disagree.

On the whole, the first three hypothesis have been found to be validated and the fourth one partially validated. Now, herewith, we give our specific hypothesis and give our conclusion against each of them.

1. Higher the educational level of the wife, greater may be the professional upward mobility of the executive. This hypothesis stands valid. The data and its analysis conclusively prove the validity of the hypothesis.
2. Higher the degree and quality of home management by the wife, greater is the executive growth of the husband. This hypothesis stands valid. The data collected and analysed showed a high degree of correlation between the home management by the wife and executive competence.
3. Higher the acceptance in the inter-personal relationship greater is the upward mobility of the executive in his profession is the third hypothesis. This hypothesis is proved. The findings affirm that healthy inter-personal relationship between the spouses has an important bearing upon executive competence.
4. The fourth hypothesis that higher the extra-professional activities of the wife such as club-going, social gatherings and meetings with the wives of other executives, greater is the professional growth of the executive. This hypothesis stands only partially proved.

## S.S.m.21. PEREIRA GLADYS MYRTLE-Environmental Protection Pressure Groups in Kerala: A Study on their Structure, Strategy and Role with Special Reference to Industrial Pollution-1986-Prof. P.R. Poduval

The study of pressure groups occupies an important place in the modern political system. Pressure groups are more active in pluralistic societies with a democratic form of government. The heterogeneous nature of organizations and groups in a pluralistic society permits its citizens to express their varying interests and desires. Democracy secures to all its citizens freedom of thought, expression, belief, faith and worship. The decentralization of power in a pluralistic society is made possible through the democratic process, where people with common interests unite in a group through elections in order to influence the government. The variety of institutions in a pluralistic society makes it possible for the members to satisfy diverse needs. This is evident in democracy, for its members have the freedom of following different ways for making a living, living in different communities, holding different religious beliefs and having different social interests. A pluralistic society is an open system and the democratic framework, within which it operates, favours the different modes of interaction. In spite of the multitude of groups and organizations, there is co-operation among groups in order to gain additional rewards from organised group effort. Thus pluralistic societies are prevalent in countries with a democratic form of government.

Pressure groups have not only influenced political parties and governments, but have also influenced business decisions from time to time. A business organization cannot function detached from the social context in which it exists, nor can it be insensitive to the pressures affecting managerial decisions in many diverse ways. A business organization receives inputs of money, people and other resources, transforms these through its production process and exports products and/or services. Hence what an organization does directly or indirectly influences every facet of society. Introduction of technology, size of company, attitude towards consumers, unions etc. affect some groups in society. Because of the variety of roles played by business, conflicts often arise to discipline business and to initiate legislative remedies. Consumerism, environmental protection groups and social demands for equal employment opportunities are some of such grass-root movements that have arisen from time to time.

The scope of the present study undertaken by the researcher is confined to "Environmental Protection Pressure Groups in Kerala", especially against industrial pollution. Research studies on pollution in the Eloor-Kalamassery industrial belt have identified the types and effects of pollution on man, animals and plants. But no scholar seems to have identified the structure, strategy and dynamics of environmental protection pressure groups as a subject-matter worthy of deeper probe and understanding.

The main purpose of the study is to identify the factors that make pressure groups succeed or fail in achieving their set objectives. The concept "pressure group" used in the thesis is defined as a social group that is not a part of the government and does not itself seek to govern the country or any specific organization in its own name, but does seek to influence the government or other organizations for its own purposes. The factors include the structure and strategies of social pressure groups and the support they receive from the environment. More specifically the scope of the present research study is to investigate:

1. Perception of and reaction to environmental hygiene/protection, environmental pollution and tactics and strategies of pressure groups against environmental pollution by the relevant segments of the public, i.e., medical practitioners, veterinary surgeons, local farmers, managers, trade union leaders and other social groups.
2. Origin, development, structure and types of pressure groups for environmental protection functioning within the Eloor-Kalamassery industrial belt.
3. Strategies and tactics adopted by environmental protection groups in Kerala to achieve their objectives.
4. Regulatory framework and public interest litigation relating to environmental pollution with special reference to the role of environment protection pressure groups in Kerala.

**Selection of the sample**

Since most of the chemical industries - industries which contribute to air and water pollution - in Kerala are situated in the Eloor-Kalamassery industrial belt, it was decided to confine the study to this area. The Eloor-Kalamassery industrial belt comprises of three Panchayats namely Eloor, Kalamassery and Kadungalloor panchayats. The total population in the three panchayats together is 79,813 (1981 census) i.e., Eloor panchayat consists of 11,192 males and 9,533 females, Kalamassery panchayat consists of 9,505 males and 8,452 females and Kadungalloor pancyayat consists of 8,894 males and 8,569 females.

Instead of attempting to cover the total population in the area, the population was segmented into 6 groups viz. doctors, veterinary surgeons, social group for environmental protection, farmers, managers and trade union leaders. Separate questionnaires were distributed to each segment.

### 1. Selection of medical practitioners

The Eloor-Kalamassery industrial belt consists of eight hospitals with a total strength of 30 doctors, 14 clinics with 22 doctors and three primary health centres with six doctors. Since the total number of doctors in the area is only 62 it was decided to represent the entire population.

### 2. Selection of verterinary surgeons

There are two veterinary hospitals in Eloor panchayat, each having one surgeon. Kalamassery panchayat has one veterinary hospital with one surgeon and Kadungalloor panchayat has one veterinary hospital with one surgeon. The total strength of surgeons in the four hospitals is four. Their number being quite small it was decided to represent the entire population.

### 3. Selection of social pressure groups for environmental protection

Since the social pressure groups for environmental protection were found to be small in number in the Eloor-Kalamassery industrial belt, the scope was widened to include all the available social pressure groups functioning in various parts of Kerala. Nearly 60 questionnaires were distributed to the office bearers of 19 associations/environmental protection pressure groups in 4 places in Kerala - 15 each for each geographical centre. Cochin, Calicut, Trivandrum and Vellore are the places where such groups are functioning.

### 4. Selection of farmers

In the case of farmers a 20% sample was drawn by using the random sampling method (Tippett's method) and nearly 120 questionnaires were distributed to 120 farmer families residing within a 5 km. distance from the Fertilizers and Chemicals Tranvancore Limited.

### 5. Selection of managers

There are 16 chemical units situated in the Eloor-Kalamassery industrial belt. At the initial stage questionnaires were distributed to each chemical unit. But lack of co-operation from the management resulted in failure to obtain the necessary data. To compensate this, it was decided to take another approach and a second questionnaire was prepared to collect data on the reactions of individual managers. Only three major chemical units were taken for the study. The study was concentrated on Unit-I consisting of all senior level and middle level managers, and 15 questionnaires were distributed. From Unit-II all senior and middle level managers were included for the study and 15 questionnaires were distributed. From Unit-III all senior and middle level managers were included for the study and 15 questionnaires were distributed.

### 6. Selection of trade union leaders

There are 11 trade unions in the three units together. Thirtythree questionnaires were distributed to Presidents, Vice-Presidents and Secretaries of each trade union.

## Methodology

As a preliminary step personal interviews were held with some selected medical practitioners, veterinary surgeons, farmers, social group for environmental protection, managers and trade union leaders for the preparation of the questionnaire. The draft questionnaire was pretested among a cross section of segments and refined for the final version of the questionnaire as tools for data collection. The original questionnaire after pretesting was modified since some of the data sought were too confidential to be disclosed. Primary data were collected through such refined and tested questionnaires eliciting responses from medical practitioners, veterinary surgeons, farmers, social group for environmental protection, managers and trade union leaders.

Data/Information were collected from secondary sources also. The following cases were prepared and presented in Chapter IV of the thesis on the basis of such secondary data/information and in certain cases by direct investigation by the researcher:

1. Periyar Bund Action Council
2. Farmers' protest against a chemical industry
3. A panchayat against radiation pollution
4. Local people against pollution caused by the Hindustan Paper Corporation.
5. The Mavoor Rayons and the Chaliyar river
6. Environmental protection demands in Kalamassery-Eloor area
7. The Silent Valley Protection Movement*
8. Bhopal gas tragedy*

*Silent Valley and Bhopal gas tragedy are included as cases at the national level, though they are not directly linked with the thesis.

The questionnaire was mailed to the sample selected for the purpose. Nearly 30% responded to the questionnaire mailed without any reminder being sent to them. In the case of others a vigorous follow-up by means of repeated reminders, personal visits, telephone calls etc., had to be made. The researcher could get nearly 50% of filled questionnaires, which is considered by any standard to give reliable data for analysis and interpretation.

## Limitations of the study

1. The main focus of the study is confined to the Eloor-Kalamassery industrial belt, but since the number of organised pressure groups in this area is quite limited, other areas in Kerala where pressure groups were organised and active have been included.
2. Though there are 16 chemical units in Eloor-Kalamassery industrial belt only three major important chemical units have been considered to get personal viewpoints of Managers and trade union leaders on pollution problems.
3. Since the development of environmental pressure groups in Kerala is a recent phenomenon adequate literature on the subject was not available and hence literature pertaining to developed countries like the U.S. on this subject had to be made use of.
4. Lack of cooperation from the representatives of the management concerning the effect of environmental pollution on man, animals and plants has had a considerable constraint on the study. In fact the topic of research "Role of environmental pressure groups in decision making by business organizations

with special reference to Kerala" had to be changed to "Environmental protection pressure groups in Kerala: a study on their structure, strategy and role with special reference to industrial pollution" as the management was very reluctant to reveal their reactions as far as pollution was concerned.

**Presentation of the thesis**

For the purpose of analysis, the study report is divided into eight chapters.

The first chapter is introduction. It has two sections. The first section deals with the nature and characteristics of the pressure groups in a pluralistic-democratic society. Consumerism and groups demanding equal employment opportunities and employment for the sons of the soil are the areas which have been introduced to show the role of pressure groups on management decisions from time to time. Section two represents scope, methodology, limitations of the study and chapterisation. Definitions of main concepts are dealt with in section two.

Chapter two gives a detailed account of the nature, characteristics and consequences of environmental pollution on man, animals, plants, materials and climate.

Chapter three deals with the environmental protection movement at the international and national scenes. The chapter describes the development and functions of the various environmental groups.

Chapter four presents six case studies of environmental protection groups that came into existence as a result of the industrial pollution in selected areas of Kerala. The national tragedy of Bhopal poison gas and the case of Silent Valley are also included in the chapter as case studies at the national scene.

The regulations laid down by the government for ensuring environmental protection and some environmental litigation cases relating to environmental pollution are presented in chapter five.

Chapter six, seven and eight are the important chapters in the thesis. These chapters present the data collected and their analysis for meaningful inferences relevant to the environmental pollution and role of pressure groups against industrial pollution.

Chapter six deals with the nature, characteristics and consequences of the environmental pollution in the Eloor-Kalamassery industrial belt as perceived by the relevant segments of society i.e., medical practitioners, veterinary surgeons, social pressure groups, farmers, managers and trade union leaders.

Environmental pollution is depicted as a system consisting of three basic components. The first component is the source of pollution. The chemical units in the area are considered to be the source. The second component consists of atmosphere, water and land from where the source emissions are dispersed. From the atmosphere, water and land the pollutants affect the receivers viz. man. animals, plants, property and the general climate. There is a unanimous view among the respondents on the negative impacts of environmental pollution on man, animals, plants, property and climate.

In an attempt to find out the different types of pollution in the area, the various relevant segments were asked to identify the types of pollution in the area. The respondents were unanimous in their opinion that there is air and water pollution. But we find certain variations in the responses given by the various relevant segments on sound and radiation pollution.

In the pollution system the third component is the receivers such as man, animals, plants and materials. During this study an attempt was made to collect data from experts such as medical practitioners on the effects of pollution on human health, from veterinary surgeons on the health of animals and farmers of the locality on the effects of pollution on crops.

Chapter seven which consists of four sections, presents the reactions of the relevant segments to issues on environmental pollution. Section I is a classification and description of the nature of complaints, tactics and strategies resorted to by farmers for redressing their grievances. The attitudes of management and government agencies to the requests of farmers are also analysed.

Section II presents the awareness of medical practitioners and veterinary surgeons relating groups working for environmental protection. Majority of them are of the opinion that the absence of organised environmental groups was one of the reasons for the discharge of effluents into air and water bodies.

Section III presents the reaction of the environmental groups to the problem of pollution. Detailed accounts of the structure, strategy and dynamics of the groups are given in chapter eight of the thesis.

Section IV gives the reactions of managers and trade union leaders to issues on environmental pollution.

Chapter eight gives the structure, strategies and dynamics of the environmental pressure groups in Kerala for achieving their objectives. Factors associated with success/failure of pressure groups against industrial pollution are discussed in detail. The structure, strategey and dynamics of pressure groups are discussed within a theoretical framework. Towards the end of the chapter the summary and conclusions of the research work are given.

**Major findings of the study**

As conclusion the following features are found to be associated with he ineffectiveness of most of the environmental pressure groups functioning in Kerala:

1. Most of the environmental pressure groups functioning in Kerala are anomic pressure groups in their characteristics than associational or institutional. Anomic pressure groups exist on adhoc problems and issues. They resort to short term tactics to overcome their immediate problems and with the achievement of such adhoc objectives the purpose of the group is achieved.
2. an adhoc-anomic pressure group may show cohesiveness in its immediate action programmes against an immediate target, but the group does not continue for want of long term objectives, structure for role differentiation and norms for its continuity.

3. Members in most of the environmental pressure groups in Kerala are mainly from educated middle class and majority of the members occupy professional/technical positions in formal organizations. There are no rules and regulations for accepting members. The directly-affected parties viz. industrial workers, managers, farmers and other local residents are not active members of the environmental pressure groups functioning in Kerala. There is no definite pattern of interaction among the members in the form of regular meetings in the absence of immediate action programmes against the management of a concern.
4. Leadership of such environmental pressure groups in Kerala is more "task oriented" than "member oriented". Task oriented groups usually fade away

after achieving their immediate objective. Continuity of such groups is blocked by absence of member oriented style of the leaders.

5. Local farmers and leaders of such pressure groups could be pacified by the management by way of offering jobs, compensation or other attractions.
6. Environmental pressure groups in Kerala do not affiliate with other organisations of similar nature, political parties or other institutions. The only exception to this is the Kerala Sastra Sahitya Parishath. In a developing society with political democracy, anomic and non associational pressure groups can survive and grow only with direct or indirect support of political parties and/or strong well established other organizations.
7. The environmental pressure groups in Kerala do not get direct support from trade unions.
8. Adhoc - anomic groups can maintain their cohesiveness by the presence of an immediate objective or by the presence of an agency for direct confrontation. When the target is vague, the strength of the group gets diluted. Similarly when the direct agency for confrontation is missing, the group may find it difficult to maintain its cohesiveness. In Eloor-Udyogamandal area, where most of the chemical factories are situated on the banks of the river Periyar, it was difficult to distinguish a single agency reponsible for pollution of the area. On the other hand in Calicut and Vellore the environmental pressure groups could succeed in directing the confrontation to specific agencies responsible for environmental pollution. From Eloor-Udyogamandal area, pressure groups with mere immediate task oriented objectives could succeed because they could identify and isolate the agency responsible for the environmental issues. Periyar Bund Action Council and litigations filed by the Eloor-panchayat against IRE are illustrative cases.
9. Most of the environmental pressure groups were resorting to dharna, protest march, submission of memorandum and other short term tactics against the management of the industrial organizations. These pressure groups did not take effective strategies in pressurising the enforcing agencies of the government; nor did they make significant attempts at influencing the government through political parties or the legislative process.
10. Another strategy the environmental pressure groups could have resorted to was approaching the judiciary for enforcement of existing laws for environmental protection and taking action against those who are violating the norms. However, majority of the environmental pressure groups in Kerala did not resort to litigation.

Though we find many of the environmental pressure groups functioning in Kerala are not effective in influencing the decisions of the management, they were very effective in creating an environmental consciousness among the public through their publications, research studies and short term tactices. This positive contribution of the environmental pressure groups in Kerala – whatever be its nature and structural characteristics – is a really significant contribution for further effective action for the maintenance of environmental hygiene.

**A note on the method of giving references in the thesis**

The method of giving reference in the thesis is slightly different from the traditional method i.e. numbering the reference and giving the details of reference immediately at the bottom of the same page. The researcher has adopted the method followed in the books of behavioural sciences, i.e., giving the name of the author, year of publication and page number in bracket immediately after the sentence and giving the detailed reference in consolidated form in alphabetical order at the end of the thesis. This method is widely acceptedd in behavioural sciences and it is easy to identify the source of reference without repetitions and expressions such as Ibid., op.cit., loc.cit., Idem, Infra and Supra.

## S.S.m.22. HARIKUMARAN NAIR, K.B.–Management of the Postal Services in India : A study with reference to Kerala Circle–1987–Prof. P.R. Poduval

The focus of the study was on problems relating to the organization and management of the postal services, customer satisfaction and perception of employees of Kerala Postal Circule on Human Resources Management Practices. The evolution of the postal system in Kerala with reference to the objectives, funcions and structure has been analysed.

The method of the study has been descriptive and analytical. the researcher goes into detail on the organization and management of Kerala Postal Services and the various problem areas. The empirical data on the perception of the employees of Kerala Postal Circle on Human Resource Management Practices followed by the department are presented, analysed and discussed.

The recommendations of the researcher include:

1. Objectives of the department should be clearly spelt out and transformed into goals and targets and communicated to the officers at different levels.
2. Internal communication system needs to be strengthened.
3. Proper structural set up to be built up for handling adhoc and seasonal enormous increases in traffic.
4. Better systems and methods to be evolved for processing of mails.
5. Proper grievance handling machinery to be set up.
6. Wage structure to be revised.

## S.S.m.23. Antony, G.–Structure of Marketing Channels of Selected Manufacturing Industries in Kerala –1987– Prof. N. Ranganathan

The objective of the study is to analyse the existing structure of marketing channals with a view to ascertain the adequacy of the present distribution system to provide the distribution services most appropriate for the merging mass production situation. The study is directed to find out the 'channel mix' used by specific industries and individual manufacturing firms, the length of the channel, the institutional and functional characteristics of the different types of intermediaries used in various industries, the intensity of distribution.

The study is both descriptive and analytical. While selecting industries, due representation has been given to different categories of industries, consumer products, semi-industrial goods and industrial products. The fifteen industries covered by the study include soaps, pharmaceuticals, packaged food & soft drinks, tyres, paints etc.

The various chapters focus attention on the multiple channel structure, additions and deletions of channel levels, institutional dynamics in the distribution system, horizontal structure of distribution by tracing the policies of intensive, selective and exclusive distribution at various levels etc.

In the Chapter 'conclusions' the author observes that the distribution barriers to entry and expansion of manufacturing firms are real and perplexing. Efficiency in manufacturing is inhibited by the bottlenecks in the distribution system and the society pays a higher price for the inefficiencies inherent in the existing structure of distribution.

The major reason pointed out by the author for this situation is that adequate managerial attention is not being paid to the distribution aspect of marketing. As a result of inadequate managerial commitment to strategic decisions in distribution, stability rather than strategic adaptations come to characterise the distribution system.

## S.S.m.24. GOPALAKRISHNAN NAIR, K.–Problems and Prospects of Marketing Indian Cardamom at Home and Abroad–1987– Dr. N. Parameswaran Nair

Cardamom is a versatile spice. It can flavourfully blended with anything edible or drinkable. Because of its odour, aromal flavour and taste, it goes extremely well with coffee, tea, milk, fruit juices, soft drinks and alcoholic beverages. It also enhances the taste and flavour of toffees, baking products and vegetable and meat preparations. In suitable quantities it makes the experience of food a more exciting one.

India produces more than 35 renowned spices of the world. Next to pepper, cardamom is the most important spice produced in India. The annual value of the total crop can be estimated around Rs. 1000 million, at present.

In view of the anticipated increase in the world supply cardamom, it is important that product and market development studies are undertaken in those countries where consumption is low so as to encourage wider uses of cardamom and cardamom products. In view of the increasing competition it is also important to strengthen the existing markets through improved marketing techniques, packaging, development of new end uses and aggressive promotional measures. This thesis is the outcome of a serious study in the above direction.

The main objective of the study has been to analyse the marketing problems of Indian cardamom and examine courses of action which will lead to increased consumption and marketing of cardamom and cardamom products both within India and abroad in the context of the anticipated increases in the Indian and world supply of cardamom.

Though few market surveys have been conducted on cardamom in India and abroad, no comprehensive study has been undertaken so far on the total marketing problems of Indian cardamom. Hence this is an original work. Maximum care was taken to make this study useful to the industry. The shortcomings have also been identified and solutions recommended for the benefit of the industry.

## S.S.m.25. KRISHNAN NAMPOOTHIRI, K.–A study of the Co-operative Banking system in Kerala–1987– Prof. P.N. Rajendra Prasad

This study is an evaluation of the working of the co-operative Banking system in Kerala which include Primary, Central and State Co-operative Banks. The thesis is divided into five chapters, viz. (1) Introduction, (2) Primary Co-operative Banks (3) District Co-operative Banks (4) The State Co-operative Bank and (5) Conclusions and Recommendations.

According to the author, the Primary Co-operative Banks, coming under the Banking Regulation Act should be given a common cadre in the State level and a separate department be formed under the State Co-operative Bank for the recruitment of the staff.

The study recommends a re-organisation of the structure of District Co-operative Banks with a view to reduce the burden of expenses of administration and establishment.

The study highlighted the need for establishing a separate department in the Kerala State Co-operative Bank for the effective supervision of primary Co-operative Banks. The State Co-operative Bank, being the apex bank, should see that the Central Banks and Primary Banks are strictly observing the principles of Co-operation.

According to the author, if the findings are recommendations made in this study are implemented properly, the co-operative Banking system in Kerala will be able to achieve commercial efficiency within the ambit of the philosophy of co-operation.

## S.S.m.26. GOPINATHA MENON, G.–Processing, Procurement and Marketing of Pepper with Particular Reference to Co-operative Sector–1988–Prof. N. Ranganathan

This study is designed to gather, record and analyse data on history of pepper, pepper production, procurement and marketing with particular reference to Kerala. The main emphasis is given to study the role of co-operative sector with regard to procurement and export efforts and also the services rendered by co-operative sector agencies under MARKETED and NAFED to pepper trade.

The study has identified causes of low productivity in pepper as the cultivation of a large number of variety of poor genetic stocks, high population of senite and unproductive vines in the gardens, unscientific inter/mixed cropping and non adoption of proper manuring, plant protection, poor shade regulation, lack of soil conservation measures and inadequate extension service.

The study contains a number of recommendations and strategies for increasing the production of pepper by 3 to 4 per cent per annum and the productivity per pepper vine.

## S.S.m.27. KEVIN, S.–A Study of the Textile Industry in Kerala with comparative reference to Tamil Nadu–1989– Prof. P.N. Rajendra Prasad

The first chapter is the introductory chapter presenting the problem, the objective and the methodology of the study.

The cotton textile industry consists of three distinct sectors, namely, mills, powerlooms and handlooms. This study is confined to the mill sector of the cotton textile industry. The cotton mill industry is one of the important medium and large-scale industries in the State of Kerala. Due to the widespread development of the handloom industry in the State, there is an environment conducive to the growth of cotton spinning mills which produce yarn, the raw material required by the handloom industry. New spinning mills are being commissioned. But the performance of the existing cotton spinning and weaving mills in the State is not quite satisfactory. Hence, an analysis has been carried out into the profitability and financial position of the cotton mill industry in Kerala. The objective of the study is to make a financial analysis of the industry covering various aspects such as cost structure, productivity, asset structure, financial structure and working capital management.

The study extends over a period of five years from 1980-81 to 1984-85 and covers all the textile mills in the State. The relevant data have been collected directly from the mills through a questionnaire and also from their Annual Reports. These have been analysed by using various techniques such as Ratio analysis, Common-size method of analysis, Correlation analysis, Inter-firm comparison, Index numbers and Funds flow analysis. The results have been compared, wherever possible, with the figures for the cotton mill industry in Tamil Nadu available in the studies conducted by SITRA (the South India Textile Research Association).

## S.S.m.28. GANGADHARAN NAIR, R.–Management of Higher Educational Institutions in Kerala–1989–Dr. C.M. George

The field of enquiry in the present study is confined to an analysis of the existing system of management of Arts and Science Colleges in Kerala. A comparison of the existing methods with recognised management principles with a view to suggest a model for the better management of these institutions has also been made. The effectiveness in mobilising and utilising resources by these institution, the leadership styles of the head of institutions and the nature of information system prevailing in them are also discussed.

The study examines the existing system of managing Arts and Science Colleges and compares the system with accepted management principles. It is found that no college is making use of a formal information system and the absence of such a system adversely affects planned utilisation of resources.

It is observed in the study that the heads of institutions of Arts and Science Colleges are over burdened with routine matters. The study suggests a functional model consisting of four functions; viz. planning, participative decision making, delegation and usage of information system for the effective management of higher education.

## S.S.m.29. ANNA, V–Women entrepreneurship in the Industrial Manufacturing Sector of Kerala–1989–Dr. N. Chandrasekharan Pillai

### Statement of the Problem

Women in Kerala are highly literate and their contribution to the agricultural and services sectors of the economy is quite significant. But their contribution to the industrial development does not appear to be so impressive. Therefore, there is a need to look into the factors behind the relatively inadequate representation of women in the industrial sector. As a prt of an attempt to fill the gap, the study endeavours to analyse the different aspects of women entrepreneurship in the small-scale industrial manufacturing sector of Kerala. To be precise, what is in focus is the trends in the growth of women entrepreneurship, Socio-economic factors motivating enterprise, profile of the units, an analysis of some specific problems faced by women entrepreneurs and their contribution to the Socio-economic growth of Kerala.

Why is industrial entrepreneurship shy in Kerala? One can further ask: what are the different Socio-political and economic factors behind the growth of women entrepreneurship? A related question concerns the institutional factors promoting and inhibiting entrepreneurial growth among women.

### Objectives of the Study

The objectives of the study are:

1. To study the pattern and extent of supply of women entrepreneurs.
2. To assess the relative effect of Socio-economic and cultural factors both as inhibitors and promoters of women entrepreneurship.
3. To examine the entrepreneurial support system - their related strengths and weaknesses.
4. To study the profile of women's industrial units.
5. To study different problems facing women entrepreneurs.

### Methodology and Data Collection

Women's industrial units are set up under different schemes in Kerala. But the scope of the present study is confined to those women entrepreneurs who have registered with the Department of Industries.

Primary data for the study have been collected from the women entrepreneurs of Kerala engaged in different trade lines. A sample of around 10 per cent (121 out of 1143) of the women entrepreneurs was selected at random or indepth study. The sample women entrepreneurs represent all the 14 districts of Kerala State. Primary data were collected using pre-tested schedules. The secondary sources of data include, published and unpublished materials, both public and private related to Women's Industries Programme.

### Limitations of the Study

This is an exploratory study based on a sample survey. The limitations of such a study is applicable in this case also. Again, a detailed comparative study of Kerala's position with other States has not been attempted in the thesis due to paucity of published data.

### Plan of the Study

The study is divided into seven chapters.

The first chapter provides a brief introduction to the study. It also includes the statement of the problem, objectives of the study, method of data collection, tools and techniques used for data analysis and a brief review of the available literature on the subject.

The second chapter provides a brief historical analysis of the emergence and growth of women entrepreneurs in India with special reference to Kerala. It also discusses entrepreneurship development programmes and organisations in the service of entrepreneurs.

The Socio-economic and educational background of women entrepreneurs is the subject matter of the third chapter. It identifies the sources of women entrepreneurship in Kerala by their Socio-economic characteristics viz., community, occupation, educational level, financial background and other related characteristics.

The different forces which induced women to step into industrial ventures and also the process of the emergence of entrepreneurship among women constitutes the core of chapter four.

The fifth chapter gives a profile of the units surveyed, with special emphasis on their age, organisational set up, capital structure, employment and sales turnover.

Chapter six deals with problems faced by women entrepreneurs in their day to day business life. It also includes suggestions to overcome such problems.

The concluding chapter, besides providing a summary of the study, highlights some of the policy implications emerging from it.

# Faculty of Humanities

## H.1. SUSEELA AMMA, B.-An Investigation into the Social Environments in Hindi Literature of Bhakti Period–1973–Dr. N. Raman Nair

The thesis deals with the Golden Age of Hindi Literature, Bhakti Period. Thorough investigation into the Social Environments of Bhakti Period through the study of various poetic works written both in Nirgun Bhakti and Sagun Bhakti. The most important aspects such as social, political, religious, cultural environments depicted in all the works of this period are clearly revealed.

## H.2. PADMINI, V.–An Analytical Study of the Suktis in the Complete Works of Tulsidas–1976–Dr. N. Raman Nair

The thesis in 8 chapters gives an analytical study of the maxims in the works of Tulsidas. The maxims of Ramcharitmanas, Dohavali, Kavitavali, Gitavali, Parvatimangal, Janakimangal, Vinayapatrika etc. are classified and dealt with in detail in the thesis.

## H.3. CHANDRIKA, R.–A Critical Study of the Influence of Gandhiji and his teaching on Modern Hindi Poetry–1976–Dr. N.E. Viswanatha Iyer

The thesis brings about the influence of Gandhiji and his teachings on Modern Hindi Poetry in 10 chapters. All the important poetical works in Modern Hindi are taken for study in the thesis. The general study of Gandhiji's teachings and their application in Hindi Literature are the main features of the thesis.

## H.4. RAJAKUMARAN, A.–Novels of Jainendra Kumar–A Study–1976–Dr. P.V. Vijayan

This thesis is a critical study of the Novels of Jainendra Kumar on the basis of literary principles, Psychological ideas and Philosophical Conceptions. Jainendra Kumar, as an epoch making Novelist has given to Hindi Novels new directions and spiritual awareness. This thesis evaluates the novels of Jainendra Kumar from different angles and outlines his importance as the founder of Modern Hindi fictions. His contributions in the development of Modern Hindi novels is evaluated.

## H.5. INDIRA DEVI, P.K–The Poetical Works of Sumitranandan Pant–A Study–1977–Dr. P.V. VIJAYAN

Sumitranandan Pant is one of the fore-runners of Chhayavadi Poetry in Hindi. This thesis is a critical study of the Poetical Works of Poet Pant. Deep study of the various aspects of Pant's Poetry is the main aim of this thesis. As a nature. Poet Pant has a remarkable position in Hindi literature. This thesis also evaluates Pant's nature-poems showing fresh approach. Language and style of Poet Pant are also analysed in this thesis.

## H.6. THANKAMANI AMMA, S-Modern Hindi Khanda Kavyas: A Critical Study (1900-1970)–1977–Dr. N. Raman Nair

The thesis is a comprehensive study of Modern Hindi Khandakavyas from 1900 to 1970. It highlights the three revolutions in the field of modern Hindi Khandakavyas. The first revolution occurred in the pre-romantic period when classical khandakavyas were written. The second revolution occurred in the romantic period when the classical form of Khandakavyas were much changed and the main trends of romanticisms had its influence on Khandakavyas. The revolution was both in the external and internal aspects. The third revolution occurred in the post-romantic period when the "new poetry" had its influence in the Khandakavyas.

The concept and structure of Khandakavya forms are fully described. About 110 modern Khandakavyas are discussed. They are classified into different groups and scientific and systematic conclusions are also made.

## H.7. ARAVINDAKSHAN, A-Novels and Short Stories of Anjeya–1977–Dr P.V. Vijayan

This thesis is a study of the fictions of S.H. Vatsyayan 'Anjeya', the Celebrated Hindi Poet, novelist, short story writer and thinker. His novels and short stories are noted for its high aesthetic order as well as its philosophical dimensions. In this thesis the novels and short-stories of Anjeya have been separately analysed and its literary relevance has also been underlined. But in the final analysis the points put forward by S.H. Vatsayan regarding the total sensibility of his creative work have been identified as follows:

1. The struggle of man with society.
2. The struggle of man with values.
3. Identity crisis of modernism and its existentialistic aspects.

This thesis is a study of literary piece of Anjeya as well as the study of contemporary thinking.

## H.8. SHEMIM ALIYAR, P.A-Historical Dramas in Hindi with Special Reference to Harikrishna Premi–1977–Dr. N.E. Viswanatha Iyer

The thesis in six chapters deals with the different stages of historical plays which depict patriotism and national integrity giving special reference to the thirty historical plays of Harikrishna Premi. A probe into these plays clearly reveal the fact that the nationality, patriotism and national integration is the pivot of these plays. His plays very well reflect the social problems also. More over there is a unique blending of imagination and historical facts in his plays.

## H.9. RAMALINGAM IYER, V–Humour in Medieval Hindi and Malayalam Poetry–1978–Dr. N.E. Viswanatha Iyer

It is a comparative study of humour in Hindi and Malayalam poetry in the Medieval period in eight chapters.

## H.10. VISWAMBARAN, T.N.–A Study of the Technique of the Hindi Drama (Post Prasad Period)–1978–Dr.N.E. Viswanatha Iyer

The thesis in 6 chapters narrates the techniques of Post Prasad Hindi Drama in detail. The different techniques of Hindi dramatic stage in general are also described in the thesis. The characterisation, dialogue etc. of Post Prasad Hindi Dramas are dealt with in detail. The sixth chapter gives the main achievements of Post Prasad Hindi Dramatic Literature.

## H.11. CHITHRALEKHA, K-Buddha and Buddhist Thought in Modern Hindi Poetry–1978–Dr. N. Raman Nair

The thesis aims at the evaluation of the principles of Buddha and Buddhist thought in Modern Hindi Poetry. Critical evaluation has been made about Buddha Charita of Ramachandra Sukla. Anagh and Yasodhara of Maithilisaran Gupt and other poetical works based on Buddha and Buddhistic philosophy in Modern Hindi Literature. This is the first work on the subject in eight long chapters.

## H.12. RAMACHANDRAN NAIR, J-Satire in Modern Hindi Poetry (1930—1960)–1979–Dr. N. Raman Nair

The thesis vividly describes the various trends of satyrical Literature of Modern Hindi Poetry with an introduction on various forms of Satire, humour, burlesque, parady etc. In Modern Hindi Poetry the predomination of Satire is established in the thesis. A comparative narration of Hasya Rasa and modern Satire has been made in this work. The thesis has been published.

## H.13. KARUNAKARAN, K, A–Comprehensive Study of the Folk Poetry in Hindi and Malayalam Literature–1980–Dr. N.E. Viswanatha Iyer

The thesis in 9 chapters gives a Comparative Study of Hindi and Malayalam Folk poetry. The work gives valuable information about the Malayalam Folk Poetry in special and a history of folk poetry in general. The folk poetry in different dialects of Hindi have also been collected for study. This is the first work made in the field of comparative study of Folk Literature in Hindi and Malayalam.

## H.14. JOSEPH, P.M-Hindi Aur Malayalam Ke Romantic Kavya Me Prem Aur Saundarya–1980–Dr. P.V. Vijayan

This thesis is a comparative study of love and beauty depicted in the romantic poetry of Hindi and Malayalam. This thesis throws light on romantic movement and its influence on Hindi and Malayalam Poetry. Love and beauty are the essence of romantic poetry. Hence this thesis is a detailed study of the romantic poetry of Hindi and Malayalam.

## H.15.—RAJALAKSHMY, A.–Social Dramas of Post-Independence Period–1981–Dr. A. Ramachandra Dev.

In this thesis the scholar has surveyed the whole gamut of post-Independence Hindi Drama with particular emphasis of social problems reflected therein. She asserts that though various trends, such as political, cultural or national are describable the most faceful undercurrent in Hindi Drama of the period is mainly related to our social milieu. Our social problems still await remedial measures even after many decades of independence. The scholar has delineated social problems carefully and dispassionately from the gross masses of dramatic literature produced during the period.

## H.16. SHANMUGHAN, M.–The Influence of Existentialism on Modern Hindi Novel–1982–Dr. M. Easwari

Existentialism is a modern philosophy. It is fundamentally based on the existence of man as an individual. It is inseparably related to the expression of man's emotions and thoughts. The post-war socio-economic, political and cultural conditions in India were congenial to the growth and development of existentialist literature. Analysing the novels from the Premchand period till present age the scholar establishes how the different aspects of Existentialism find expression in Modern Hindi novels. He concludes that Hindi Novelists accepted it in their writings with sufficient Modifications and Changes as suited to their feelings and emotions and the living conditions in our country.

## H.17. THOLASI RAMAN, M.S.–A Comparative Study of Main Trend of Modern Swachandvad in the poetry of Hindi & Tamil–1983–Dr. N. Raman Nair

The thesis is a comparative study in seven chapters with a thorough analysis of the principles Romantic Literature in general and evaluation of Hindi and Tamil Romantic poetry. Explaining the vairous situations how Romantic trends developed in Hindi and Tamil the entire romantic works are analysed and a comparative evaluation is made. This is the first work of its kind.

## H.18. VELAYUDHAN, K.K.–Contributions of Representative Poets in the Development of Modern Hindi Criticism on Poetry–1983–Dr. P.V. Vijayan

This thesis throws fresh light on the arena of Modern Hindi Criticisms. This thesis deals with criticism on Poetry by Poets. Summary of this thesis is that poets representing various trends of Modern Hindi Poetry have enriched Modern Hindi criticism. Among the Hindi Poets, Jayasankar Prasad; S.H. Vatsyayan Anjey and Muktiboth have got important position in Hindi Literature as critics too.

## H.19. JALAJA, V.S.–Sohanlal Dwivedi Ka Kavya (Poems of Sohanlal Dwivedi)–1984–Dr. N. Raman Nair

The thesis in 8 chapters presents a comprehensive study of the poetry of Sohanlal Dwivedi. The patriotism in the Kavyas of Sohanlal Dwivedi is a notable feature of the thesis. The thesis also brings out the details about the influence of Gandhism in the Kavyas of Sohanlal Dwivedi. The children's Literature and the lyrics written by Sohanlal Dwivedi are also dealt with in detail in the thesis.

## H.20. MOHANAN, N.–A Study of Elements of Alienation in the works of Mohan Rakesh–1984–Dr.A. Ramachandra Dev

This, as per expert opinion, is one of the best thesis ever written in Hindi. The problem investigated is unique in every respect and reveals certain very important aspects of modern literary thoughts, on the basis of the works by Rakesh. 'Alienation' is a mental situation deeply permeated in modern literary world. Rakesh is a multi-faceted personality and the researcher has successfully analysed and studied his works in the light of 'Alienation'.

## H.21 CHERIAN GEORGE–Soor Sagar Aur Krishna Gatha–Ek Thulanatmak Adhyayan–1984–Dr. A. Ramachandra Dev

This thesis presents a critical appraisal of SOOR SAGAR AND KRISHNAGATHA. The former is the repository of Bhakti poetry in Hindi and the latter is the most charming and soul-stirring lyrical narrative in Malayalam. Devotion to Krishna has been an inexhaustible impetus to both the doyens, Soordas and Cherussery, though they lived in total oblivion with each other. This study reveals the fundamental unity and indivisibility of Indian culture and literature.

## H.22. NARAYANAN NAMBISSAN, K.–Development of Grammar in Hindi and Malayalam Based on Classical Texts.–1984–Dr. N. Raman Nair

This is a comparative study of the development of grammar in Hindi and Malayalam. Sanskrit and English grammar are adequately verified and used for the purpose. In the first chapter ancient grammar texts of Sanskrit, Prakrit and Apabhramsh are referred and the basic principles of Hindi, Malayalam Grammar are compared and contrasted. In the second chapter complete ancient and modern grammar treatises are analysed and basic materials are noted. In the third chapter all books of Grammar in Malayalam are made use of for the study. The development of Malayalam language and grammar are dealt with in detail. Fourth chapter of the thesis deals with the different parts of speech in Malayalam and Hindi while in the fifth chapter the number of these languages comparison contrast and conclusive findings are also given. In the sixth chapter the sentence construction in Hindi and Malayalam are studied. The seventh chapter is a conclusive one where based on the studies in six chapters basic grammar equivalents are derived and the specialities and differences found in Malayalam and Hindi Grammar are evaluated. This study enhances the knowledge in the field of Malayalam and Hindi Grammar.

## H.23. ASHA, B.S–The Society as Reflected in Hindi and Konkani Proverbs–1984–Dr. L. Suneetha Bai

The thesis "The society as reflected in Hindi and Konkani Proverbs" in 6 chapters gives a detailed picture of the societies reflected in Hindi and Konkani proverbs with their similarities and dissimilarities. The different phases of the society viz. the caste system, family relationships, place of women in the society, customs and manners, Code of Conduct, different beliefs, religious rites, rituals etc. are dealt with in detail on the base of the proverbs in Hindi and Konkani. Both the Societies reflected in Hindi and Konkani proverbs have common features which they acquired from one common source, i.e. the ancient Indian Society. The researcher has proved in this study that both the societies, though different in their outer structures have a common origin with the important features of the ancient Indian Society.

## H.24. SASIDEVAN, D–A Study of the Moral Concept in Modern Hindi Novels–1985–Dr. S. Shajahan

This study mainly concentrates on the changing concept of moral values in Hindi novels written during the post-Independence period. The influence of the socio-economic conditions on creative writing has been established at the very outset. Further it has been proved that the moral values have a time oriented linkage with creativity and hence the novels written before Independence are more aligned to traditional values while those written during the post-Independence period echo the voice of outrage and distrust based on subjective experience. The new generation wants to unravel the unseen dimensions of moral values based on free sex and unchecked relationship between man and woman. The pre-Independence period writing shows more commitment towards society while the writers of younger generation are more interested in explaining the moral values on the basis of individual experience.

## H.25. RITTY JOSEPH, M: Khadiboli Hindi Kavya Me Pauranic Patra–1900–1960–1985–Dr. L. Suneetha Bai

The thesis 'Khadiboli Hindi Kavya me Pauranic Patra' consists of 8 chapters which present in them mainly the study of the pauranic characters depicted in Modern Hindi poetry from 1900 to 1960. The pauranic characters with their ancient ideals and modern realistic thoughts pictured in the Khadiboli Hindi poetry is a vast subject for research and the thesis 'Khadiboli Hindi Kavya me pauranic patra' presents a deep study of these characters in their old form and new outlook.

The main conclusions of the thesis are:

The modern Hindi poets moulded the age of pauranic characters in such a way to give picture of the modern society. The revivalists like Maithilisaran Gupta tried to reveal the ancient Indian culture and ideals through the pauranic characters. The revolutionary poets like Ramdhari Singh Dinkar expressed the revolutionary ideas through these characters for the development and progress of the modern age. These poets searched in the pauranic characters the reasons for the most modern tendencies of human mind such as horrow, frustration, aimlessness etc. They changed the old characters according to new impulses of the modern age such as intellectualism, Gandhism, Humanism, uplift of women, socialism, Marxism, Symbolism, Reflectionism, Psycho-analysis etc. Some of the characters are completely changed, while the others are only partly changed. The pauranic characters with super-natural powers and divine attributes stepped into the modern world as the modern men of the modern society.

## H.26. RAJAN, C.S–Jung Ke Kaladarshan Ke Alok Mein Ajneya Kavya Ka Adhyayan–1985–Dr. A. Ramachandra Dev

This thesis opens an entirely new vista in literary investigation based on principles propounded by the great philosopher - psychologist C.J. Jung. The researcher has focussed his attention on the poetry of S.H. Vatsyayan, the lover of Hindi literature. Such an attempt has not been made in Hindi hitherto, to the best of our knowledge and information. The scholar has critically analysed and shed new lights on almost all images and archetypes employed by Ajneya in his poetical works.

## H.27. VISWAM, V.V–Adhunik Kavya Pravrittiyom Ke Roopayan Mein Nirala Ka Yog–1985–Dr. A. Ramachandra Dev

This makes a thorough study of Nirala's poetical works and arrives at the conclusion that Nirala, the prodigious genius, was the chief architect of modern Hindi poetry and he should be accredited with the title of 'The Creator of Nayi Hindi Kavita'. The analysis of the personality of the poet is enchanting to the core and based on irrefutable documentary proofs.

## H.28. SHEELA V.P–Poetical Works of Girija Kumar Mathur: Sensibility and Technique–1985–Dr. P.V. Vijayan

Sri Girija Kumar Mathur is one of the outstanding Poets of Modern Hindi Poetry. His Poetry ranges from romantic poetry to contemporary poetry. The thesis is a critical study of Poetical Works of Mathur with special reference to sensibility and technique. The thesis evaluates poetic sensibility of Poet Mathur from various angles–personal, social, cultural, historical, political and natural. Images, symbols, language and metre are also discussed in his thesis. The thesis is an essential tool in the appreciation and understanding of Mathur's Poetry.

## H.29. CHANDRANGADAN, A.R–Keral Mem Hindi Sikshan Ka Vikas Aur Malayalam Bhashi Chatrom Ki Samasyayem –1986–Dr. N. Raman Nair

The thesis is an inter-disciplinary study since the researcher is a Professor of Education. The thesis evaluates the major and minor problems related to the teaching of Hindi to Malayalam speaking students of Kerala. The solutions for the problems are also given. The speciality of the work is that the researcher has conducted several project works and concluded his findings.

### H.30. SUBRAMANIAN, T.V.-The concept of Sex in Hindi Short Stories of the Post Premchand Period 1935-1960.-1987-

### Dr. N. Raman Nair

The thesis envisages a new horizon in the study of the concept of sex in Hindi short stories after Premchand. The modern Hindi short stories are not aimed in telling a story but are dealing with psychological aspects and sexual life of people in this age. The aim and possibilities of the subject are elaborated in the first chapter and in the second chapter based on sex and sexual attraction in the society the stories of Jainendra Kumar, Bhagavathi Charan Sharma, Bhagavati Prasad Vajpayi, Chandragupta Vidyalankar, Tharachand Joshi, Upendranath Ashk are analysed and evaluated. The third chapters aim at the short stories of Yashpal in which sexual relations are described and the fourth deals with the stories of Ajney in the same context. The fifth is a long study of the stories of Mohan Rakesh, Rajendra Yadev and Kamaleswar. In the stories of these writers sex has an important role to play. The centrifugal point in most of the themes is sex. It seems that human life is very much influenced by sex.

Towards the end the thesis concludes with a remark that Kama Bhavana is the basic principle of human life. Various natural and unnatural forms of sexual relations, sexual life and attractions that exist in the society are vividly and widely evaluated. The thesis is a study of sixty one famous stories in Hindi literature where sex has a better role. This study enhances the psychological, physical social aspects of sex described in short stories of Hindi between 1935-1960.

### H.31. SUDHA BALAKRISHNAN-Changing Concept of Womanhood in the Short Stories of Hindi Women Writers (1960-1980)-1987-Dr. N. Shajahan.

This thesis while projecting the message of liberation of Indian woman, has attempted to bring out quite a lot of social, sociological and psycho-social data for the first time, which should be deemed as a welcome addition to Hindi literature. The researcher had gone deep into the details of the creative urge of the women writers put out only in a background of inhuman exploitation of the women folk of India. The incidents and situations of the stories have two different dimensions which have to be analysed on social and personal levels. The characteristics are real and their reactions to situations are quite understandable and their conclusions are meaningful. The women writers in tact have intact knocked down the concept that woman is always weak. The resurgence of womanhood points out that the ushering of an era of woman's activism is not far off.

### H.32. VANAJA, K-A study of the Prose Writings of Ananda Shankar Madhavan-1988-Dr. N. Raman Nair

The thesis comprises seven chapters evaluating the prose works of Anand Shankar Madhavan, a famous Hindi writer from non-Hindi speaking area i.e., Kerala. Ananda Shankar Madhavan's poetical works have been studied for Ph.D. Degree from different Universities but his prose works are evaluated for the first time in this thesis. His novels, short stories, Essays, Biographies and other Prose writings are analysed his place in Hindi literature is established.

### H.33. KRISHNAN NAIR, P.V.-New Hindi Poetry – And Aesthetic Study-1988-Dr. P.V. Vijayan

This thesis displays a new approach in the study of New Poetry. The thesis contains study of aesthetics as well as New Poetry. The important aspects of aesthetics, such as images, symbols and myth are analysed in this thesis.

This thesis throws light on aesthetics and criticism. Images, symbols and myth are very important in the study of Modern Poetry. Showing a fresh approach in analysing images, symbols and myth, the thesis helps understanding and appreciating New Poetry.

### H.34. SUNNYKUTTY KURIAN.-Hindi Ki Anchalik Kahaniyam: Phaneeswar Nath Renu Shivaprasad Sing Evam Markandey Ke Visesh Sandharbh Mein-1988-

### Dr. A. Aravindakshan.

Regionalism in short story is a new area of research. The thesis deals with the regional (folk elements) in modern Hindi short story. The rustic atmosphere of these stories has its own beauty and creativity.

The works of three major regional short-story writers have been taken for detailed study.

The thesis underlines that the study of regional stories are not merely the study of some of the literary pieces. This study is of our contemporary rural life too. The question of "national literature" is quite relevant today. Actually the regional story projects the idea and spirit of "national literature"

### H.35. USHARANI, G.-Comparative study of the Vocabulary of Hindi and Konkani-1988-Dr. L. Suneetha Bai

The thesis "Comparative Study of the Vocabulary in Hindi and Konkani" presents in 5 chapters a deep study of the words of Hindi and Konkani language with their similarities and dissimilarities. A historical and comparative study of the vocabulary of Hindi and Konkani reveals the peculiarities of words in both languages. The words in both the languages are divided mainly into four classes viz. Tatsoma, Tadbhava, Desi and Videsi according to their similar sources. The thesis based on close and detailed observation of the vocabulary of both Hindi and Konkani language attempts to prove the fundamental unity of these languages. Both the languages have undergone changes due to their environmental influences and external contacts. These changes are more in Konkani than in Hindi. The thesis highlights the common noticeable characteristics and distinct features of Hindi and Konkani vocabulary.

### H.36. THIPPUSWAMY.·Harishankar Parsai-Life and Works -A study-1988-Dr. N. Raman Nair

Harishankar Parsai is one of the famous living prose writers short story writers of sarcasm and humour. He has contributed profusely in this field and the impact of his literary works has changed the society a lot.

The preface deals with the personality of Parsai's and concise idea of his works. The purpose of the research work is to critically analyse the works of Parsai'sto assess his place in literature and to evaluate his contribution to Indian literature in general and Hindi literature in particular. In the first chapter of the thesis the personality of the author as revealed in his literary works are thoroughly analysed and studied. Parsai creative energy is the real outcome of his personality. In chapter two the researcher has looked into the meaning and scope of the nature of Vyangya in Parsai's works. Here various forms of Vyangya in western world like humour, comic, irony, satire and burlesque and Indian form of Vyangya vakrokti, dhwani are described and these forms as utilised by the author are emphasised.

Chapter three of the thesis is the study of the development of Vyangya in Hindi literature. The tradition of Vyangya in Hindi literature is dealt with and Parsai's gift of the legacy of rich heritage of Hindi literature is analysed and studied in this chapter. Fourth chapter is devoted for the study of Parsai's ideology and philosophy of life. As a writer Parsai has influenced contemporary society through his works, and has left messages for the future generation. Parsai has satired the contemporary human evils and shortcomings of the society. As a messaih of human destiny, writer longing for woman liberation movement, his outlook of manist philosophy, his views of modern life and his art of writing are the fields which are vividly studied in this part.

The fifth chapter is the unique one in originality and evaluation which deals with the world of fiction of Harishankar Parsai. His humanism the satiric approach towards the corrupt society and social evils are studied and Parsai's views are evaluated here. In the sixth chapter the researcher has analysed Parsai as an essayist. The conclusive remark is that Vyangya is the most important of Parsai's writing craft–Vyangya rules supremes in his essays. The seventh is the final chapter where Parsais arts of writing and style are put to acid test. The powerful command and grip over language and style of Parsai are revealed here in their fuller sense. Parsai's always shows tremendous self confidence in telling authoritatively what he wants to say. In Parsais style there is a peculiar usage of figuritiveness. While depicting any character he uses such vocabulary that the joys and sorrows of that character become alive. The thesis also evaluates the message of the writer as well as his aims of literary outputs. Satire is the wonderful media through which a writer can tell the society what it is. Thus highsounding aim of Parsai is fully studied for the first time through this thesis.

## H.37. THOMAS, M.J–Hindi Ki Pragadivadi Kavitha: Thrilochan Ki Kavitha Ke Visesh Sandharbh Mein–1988–Dr. A. Aravindakshan.

The thesis is a study of progressive tendency of Hindi poetry which emerged as a prominent literary outlook after romanticism. Thrilochan, one of the stalwarts of progressive poetry in Hindi has a unique place in modern Hindi poetry. His poetry is just like a symphony in which poets' social manifestations as well as his urge for pure poetry find equal place. He is a poet of the real rural folk.

Progressive poetry in Hindi has been studied extensively. Major portions of the thesis are devoted to the study of the different aspects of Thrilochan's poetry.

## H.38. REMA DEVI, C–Predominant Features of the Poetical Works of Haribans Rai Bacchan.–1989–Dr. M. Easwari

The thesis is a critical analysis of the works of Dr. Haribans Rai Bacchan on the basis of their predominant characteristics. It satisfactorily establishes that Bacchan's poetic genius grew in conformity with the journey of his life. Highlighting the varigated tendencies in the works of Bacchan, the Scholar unequivocally proves that Bacchan is one of the most powerful personalities in Modern Hindi Poetry.

## H.39. RAVI, A.K–Impact of Dialectical Materialism on the Novels of Yashpal.–1989–Dr. A. Ramachandra Dev

In this thesis the scholar has surveyed the impact of Dialectical Materialism on the novels of Yashpal, as propounded by Karl Marx and other exponents of Marxism.

Yashpal was a born revolutionary. He dedicated his whole life to the noble cause of uplifting the mute millions of the down trodden people in India. He regarded art and literature as the most effective instrument for the historic struggle aimed at the ultimate emancipation of the toiling classes. The thesis asserts on irrefutable grounds that the most prominent characteristic of Yashpal's literary works is inspired by the theory of Marxian dialectics.

## H.40. LATHA, K–Rural Life in Hindi Novels of Post Independence period (1950–1975)–1989–Dr. S. Shajahan

The relevance of the study of rural life in modern times cannot be ruled out as even after forty-five years of independence, the rural areas still remain under-developed. With a view to attract the attention of one and all to this sad situation a good number of Hindi writers had tried their best to depict the life of modern Indian village in its most realistic form.

The study of the rural life deserves greater significance in the context of the gap which is widening day by day between the life of the cities, industrial areas and the villages. The village folk who had sweet dreams about future found themselves left in the lurch by the rulers and political parties. The deep sense of anguish and frustration of the villager, the demoralising influence of the cities and the contaminated socio-political set up of the villages are a few of the many points which had drawn greater attention of the writers.

The study is mainly concerned about the complete Novels of Nagarjun and Phaneeswarnath Renu. As Dr. Shiv Prasad Singh's "Alag-Alag Vaithrani" and Rahi Masoon Raza's "Aadha Ghav" are works of remarkable stature in the field of regional novels, they are also included in the study.

These writers are not uniform in their outlook. Every writer had tried to see the village and its rurality through different angles which is complementary. Hence a special study of the Novels in total makes the reader to feel that the Independent India and its village life is much more in distress, dilemma and dilapidation than what has been imagined. Thus regional novelists fulfilled their commitments towards the society by making us to feel the disguesting reality.

The study yields remarkable result in the sense that the concept of life in the rural areas have undergone thorough change and the writers have tried to understand and unveil the realities. This is done in a special manner which is the characteristic peculiarity of each and every writer. The style and diction are different but the underflowing stream of rura conscious as is one and the same.

## H.41. LATHIKA BAI, R.-Lokayatan Aur Paravarthy Pant Kavya -1989-Dr. N. Raman Nair

This is the first research study of its kind to project a Ph.D thesis on Lokayatan and Paravarthy Kavyas of great poet Sumitranandan Pant, the Jnanapeedh prize winner. The thesis is divided into eight chapters. In the first chapter the personality of Pant is revealed along with a long treatise of life sketch of Pant. The influencies of Tagore, Sarojini Naidu, Kalidas, Bhavabhuti; English poets Wordsworth, Shelley and Keats and great Thinkers like Vivekananda, Pathanjaly, Tolstoy, Ruskin and Carlyle as well as the philosophy of Aravindan are narrated and evaluated in this chapter. In the second chapter the great epic work of Pant 'Lokayatan' is put under serious study where the epic qualities of the work poetic talents of the author are enumerated. The story goes upto Gandhiji, and reveals Indian motto of Dharma, Artha, Karma and Moksha through imagories and symbols. In the third chapter later 12 works of Pant are studied in detail and conclusion remarks are given. In the fourth chapter the philosophical thoughts of Lakayatan and later works are dealt with Marxism and Gandhism which influenced the poet are evaluated here. In chapter five the social and political thoughts of Lakayatan and later works are described and evaluated. Poets all visions are evaluated in this chapter. In the sixth chapter the form and technique of Lokayatan and later works are the main theme of research study. Seventh chapter inclusted for the study of imagination and portrayal of nature in Lokayatan and later works. Pant is one of the greatest poets of nature in Hindi. Nature is profusely portrayed in his later works also. In the last chapter, the conclusive remarks of the research work are given. From 1964 onwards, which is the third phase of Pants' poetry a philosophical poet is evolved. In the last phase Pants' philosophical moods and humanistic tendencies, national enthusiasm and principles of modern values in life earmark in his works. Poet Pant as a thinker is fusing all valuable principles of philosophy in the world into his poetry during this period. As one stands for free love, free marriage but longs for a society intermingled with old and new values Pant has opened these facts in the works of this period. This research work proves that Pant has achieved much but changed less and from materialism to spiritualism he makes a useful journey and tried to make them both meet. The thesis emphasises the poet's message of peace, world fraternity and unity for a prosperous future.

## H.42. CHACKO, P.J.-Kavyadharm ke sambandh mein T.S. Eliot Evam S.H. Vatsyayan ke sitdhantom ka thulanatmak adhyan-1988-Dr. A. Ramavchandra Dev.

The thesis is a comparative study of function of poetry propounded by T.S. Eliot and S.H. Vatsyayan and it throws light upon the rich principles of criticism in English and Hindi. The Thesis investigates all aspects of criticism pertaining to Classicism and Romanticism.

T.S. Eliot and S.H. Vatsyayan have their own theories about the function of poetry. Both agree that the poet creates a poetry with great effort. In this creation he is influenced by his surroundings and immediate happening. The social and cultural surroundings have a major part in the creation beacause he is also a part of the society.

In the creative process poet is only a medium, through which various kinds of feelings, emotions and experience get new form which is not of his own but a universal ie. common to all. Poetry is not a medium to express poet's own personality, but he should be impersonal in the process of creation.

For this impersonal aspect the poet should surrender himself to the great tradition, which precedes him. He is not actually creating, but connecting his feelings, emotions and experiences to the great tradition which is omnipresent.

Language is a product of culture, poetry is communication. So the poet uses such language which helps proper communication. Only with the communication a poetry is created. Symbols and images are used for this.

Poetry creates a self in man. He will get more awareness of his society. Poetry reminds him of his duties towards society. Above all poetry gives happiness to man.

# Faculty of Environmental Studies

### **E.s.1. KANAKAVALLI SUSARLA, S.–Effect of some toxic metals on selected phytoplankton of Kerala Waters–1987– Dr. K.P. BALAKRISHNAN**

Physiology of *Scenedesmus bijugatus* and *Nitzschia palea* in their exponential growth phase in relation to Mercury, Cadmium, Copper, Lead and Zinc, at sub lethal levels individually and in various combinations was studied. Eleven parameters were selected to evolve a comprehensive picture of metal-phytoplankton interaction.

Photosynthetic production of the species varied and respiration in majority of the cases was elevatedd. The pigment content of both the species increased manyfold in all but 2 of the 33 combinations of metals studied for each species. The enhanced phtosynthetic carbon flow into pigments in majority of the instances and into lipids in few others showed that the effect of metals in low concentrations is not different from that of light and nutrient limitation. The reduction in growth, protein and lipid in many instances inspite of increased production rate and phosphate and nitrate uptake showed the total disturbance in phytoplankton physiology in presence of metals. The nitrate and phosphate starvation, if present, is not physical but physiological as their uptake was unaffected.

Increase in chlorophyll *a* was accompanied by decrease in pheophytin and *vice versa*. Pheophytin is probably not the degradation product but a chlorophyll reserve at least in these instances. No direct correlation between chlorophyll *a* concentration and production was found. The low level of chlorophyll when found, did not affect the ratio of carbohydrate, protein and lipid, if Carotenoids were present in greater quantity suggesting the importance of Cartenoids in metal toxicity studies. The alteration in the ratio of protein, carbohydrates and lipids was found to be the major effect of the metals. The increase in protein, when occurred, was accompanied by reduction in growth and probably represents the unused fraction and hence should be considered only apparent. Increased in carporation of carbon into carbohydrate, lipid and pigment moities along with varying production and respiration rates, showed that the effect cannot be studied conclusively based on these parameters. Productivity computation of polluted waters may be misleading if based on chlorophylls alone.

Significant variations in all the parameters studied showed that the metal phytoplankton interaction is a complicated one, expressed in different parameters during exponential growth phase.

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# Faculty of Marine Sciences

### **M.S.1. CHERIYAN, P.V.–Studies on Sphaeroma Terebrans Bate of the Port of Cochin–1973–Dr. C.V. Kurian.**

*Sphaeroma terebrans* Bate, one of the most destructive wood-boring isopod crustacean occurring in the Cochin harbour region was taken up for investigations on its habitat, breeding, attack on timber, salinity tolerance and respiration. The respiration of the animal under different stresses was noted using an instrument fabricated in the laboratory.

Of the various hydrographic conditions of the Cochin harbour region studied, salinity is found to be the most fluctuating factor and the variations are largely influenced by the seasonal rain fall from one side and the tidal currents on the other.

In spite of the great fluctuations in salinity, *Sphaeroma terebrans* occurs throughout the year in the Cochin harbour region, though their number varies in different months.

Exposure tests show that *Sphaeroma terebrans* can remain for about 20 to 24 hours outside water in a damp atmosphere.

Field studies in the Cochin harbour region reveal that the species breeds throughout the year and animals of 5 mm length have been found to carry eggs in their brood-pouch. A sudden rise in breeding starts at a time when there is an abrupt fall in the value of salinity due to heavy rain fall. Intense breeding and the consequent overcrowding can be considered as factors influencing the migration of the species. However, the high rate of breeding in the monsoon period does not appear to help the species to find new areas of settlement due to high turbidity and fast currents. The majority of the migrating forms are of a size between 5 mm and 7 mm.

Water temperature variation does not appear to play any important role in the breeding of the species in the region under investigation.

Studies on the distribution of the various size group of the animals found in their burrows show that they are gregarious in habit.

Laboratory tests reveal that *Sphaeroma terebrans* had a high salinity tolerance capacity. The animals acclimated in 30%o salinity and transferred directly or gradually to different salinity media show that their higher lethal level is 50%o salinity and lower 0.5%o. But for those animals acclimated in 5%o salinity the higher and lower lethal levels are 40%o and 0.5%o, respectively.

Specimens of *Sphaeroma terebrans* were acclimated in 5%o and 20%o salinities and their rate of respiration in these media was determined. The regression values ('b' value) were calculated using the method of least squares to study the relationship of body size to oxygen consumption. The value of 'b' obtained in 5%o salinity is 0.4463 and that in 20%o is 0.3428; but these values are not significantly different statistically thereby showing the existence of similar metabolic types of the same species living in two different salinity environments. However these values are different from the generally known values in Crustacea which vary from 0.67 to 1.00.

The experiments on respiration show that it is difficult to assign a particular 'b' value to all animals of a particular group and sometimes even to a particular species as the value depends upon the past environmental conditions of the animal as well as experimental conditions.

The rate of respiration of the animals acclimated in 5%o salinity is comparatively lower than that in those acclimated in 20%o.

Determination of the rate of respiration of *Sphaeroma terebrans* when salinity media were suddenly changed was done by transferring animals which were acclimated in 20%o salinity, to higher and lower concentrations. The maximum rate of respiration was in the acclimation medium of 20%o salinity and as the salinity of the medium increased or decreased the rate of respiration diminished.

In all the weight groups of animals (15 mg, 30 mg, 45 mg, and 60 mg), except in 15 mg animals, a well demarcated critical level in higher media is seen starting from 40%o salinity onwards and in lower salinities the critical level for all weight groups is seen from 1%o salinity and below.

The decrease in the rate of respiration in the lower salinity media observed in the present studies agrees with the results reported in the studies on *Balanus balanoides, B. crenatus Balanus amphitrite communis* and *B. tintinnabulum tintinnabulum verrucosa*

The rate of respiration under falling oxygen tension in different salinity media showed variations. In general, the rate of respiration remained the same from 140 to 120 mm Hg pressure of oxygen.

Under laboratory conditions, the critical level of oxygen was found to be 100 mm Hg pressure of oxygen and this is comparatively a high value reported for Crustacea. Below the critical level of oxygen the rate of oxygen uptake gradually decreases.

In the same salinity medium statistically no significant difference was observed in the lethal level of oxygen for the different weight groups of animals.

In salinities 5%o and 30%o there was no significant difference in the lethal level of oxygen. However, below 5%o and above 30%o salinities there was marked change in the lethal level.

## M.S.2. DAMODARAN, R.–Studies on the Benthos of The Mud Banks of the Kerala Coast – 1973 – Dr. C.V. Kurian

An investigation on the meiobenthos and macrobenthos of a mud bank on the South West Coast of India was carried out during 1966-1968, based on collections of bottom deposits, bottom fauna and hydrographical data from 8 stations in two profiles off Narakal. Meiobenthos samples taken from two other mud bank regions (Alleppey and Calicut) were also utilized for comparative study.

The formation of the mud bank at definite localities along the South West Coast of India is a strange phenomenon for the region and an attempt has been made to bring together all the informations available and discuss the different aspects of the problem.

A study of the hydrographical conditions of the region showed that there was marked seasonal variation in the temperature and dissolved oxygen at the bottom, the minimum being observed during the South West Monsoon. (Temperature 4m: 30.8°C. to 24.75°C; 21m: 28.8°C. to 22.0°C; Dissolved oxygen 4m: 5.85 to 1.02ml/L; 21m: 4.23 to 0.15ml/L.)

Annual variation of bottom salinity was not considerable except at near shore stations (4m.) where it recorded values as low as 20.7%o during South West Monsoon.

A study of the inorganic phosphorus in the bottom water at the stations showed that the high values (5.39 to 8.02 $\mu$g. at./L.) occurred during July and August and the low values (0.07 to 0.14 $\mu$g. at./L.) between October and January. The intensity of total phosphorus followed the same trend as in inorganic phosphorus but high values were observed during February and March.

Bottom sediment in the region was mostly silty clay. Within the 10m. line the sediment showed seasonal variation in their sand, silt, clay percentage, the clay fraction being more prominent at 4m. depth during the active period of the mud bank, while at 8m. depth there was a decrease in the finer fraction of the sediment during the above period. The sediment between 10m. and 21m. depth was relatively stable throughout the year.

The organic matter in the sediment varied from 1.97% to 3.57%, the maximum being in the stations with high percentage of clay.

Macrofauna was constituted mainly by deposit and detritus feeders. Polychaetes and molluscs formed the bulk of the fauna in all the stations (about 90 to 95%). Polychaetes were more numerous within the 10m. line and molluscs in the deeper stations. Heavy spat fall of *Nucula* sp. was observed in the region during March to October but they failed to survive.

Meiofauna consisted mainly of nematodes, foraminiferans, harpacticoid copepods and ostracods. Maximum number of meiofauna was noticed in fine sediment.

Studies on the vertical distribution showed that about 66.5% to 88.5% of the meiofauna occurred in the first 2 cm. of the deposit.

It is suggested that very low oxygen content of the bottom for long periods might be one of the factors that limit the abundance of the macrofauna (infauna) in the region. However no mass mortality of infauna has been noticed during the periods of low oxygen concentration, which might be due to the capability of some of these organisms to survive such adverse conditions. The epifauna of the region appears to migrate to shallower regions during this period.

The upwelling and resulting low oxygen concentration in the bottom water in the deep shelf region of the S.W. Coast of India is suggested as one of the reasons for the crowding of prawns in the inshore regions before the beginning of the S.W. Monsoon. With the onset of the Monsoon the low oxygen water creeps into the inshore regions also, resulting in the movement of the prawns further inshore to the very shallow regions where oxygen concentration is comparatively high. This may be an explanation for the large prawn fishery in certain mud bank regions during the S.W. Monsoon.

Meiofauna and Macrofauna (infauna) showed a decrease in intensity in the 4m. depth, which might be due to the unconsolidated nature of the sediment. An increase in the meiofauna was observed outside 10m. depth during the S.W. Monsoon where the deposit is more stable and predators are less during the period.

Biomass of the macrofauna suggest that they make only a small contribution towards the food of bottom feeding fishes and other forms. High values of meiofauna biomass show that meiofauna may be important as the food of bottom feeding forms especially for prawns which form an important fishery in the S.W. Coast of India.

## M.S.3. SAKTHIVEL, M. – Studies on Euthecosomata of the Indian Ocean – 1973 – Dr. C.V. Kurian

This study was based on 1927 plankton samples collected during the International Indian Ocean Expedition (1960-65) and 180 collections from six "Seasonal Biologiccal Cruises" of Australia. The study includes systematics of 21 species, ecophenotypic variations, geographical distribution in relation to the monsoonal changes, annual, variation along the meridian 78°E, seasonal and diurnal variations in the West Australian Sea and the vertical distribution in relation to the thermocline.

The suborder Euthecosomata (Order : The cosomata, Opistho-branchia, Gastropoda) comprises a group of holoplanktonic molluscs having 2 families, eight genera and 32 species. In addition to the 21 species listed, a new sub-species of *Creseis virgula* has been described and an aberrant form of *Clio* sp. is remarked upon. The cosmopolitan species like *Limacina inflata* and the sub-species of *Creseis virgula* show ecophenotypic variations in different parts of the Indian Ocean especially in the Red Sea. Species of *L. inflata, L. lesueuri* and *Cavolina globulosa* acted as indicator organisms. The major centre of production of euthecosomes is found in the area off the Somali and Kenya coast. The areas off Java, off Madras and the Gulf of Aden are also productive areas for most of the species. Maximum number of species is observed around 20°S in the West Australian Sea and the minimum in the Arabian Sea and Red Sea.

The mean frequency of occurrence of euthecosomes at different latitudes reveals 4 main types of dominance between 20°N and 40°S.

A total of 10 patterns of distribution are elucidated in the Indian Ocean, based on bio-hydrographic boundaries.

The seasonal variation in abundance is very prominent, most of the species reaching their peak abundance in the western half of Indian Ocean during SW monsoon. The peak period of chlorophyll during August coincided with the peack abundance. The distribution of euthecosomes in relation to the thermocline during day and night reveals that the thermocline is not a barrier for distribution. As the diurnal variation is very prominent, light is considered to be the major limiting factor in the vertical distribution of euthecosomes. The annual variation along 78°E showed that a large number of species are more in the first year than in the second year.

## M.S.4. RAMACHANDRAN NAIR, P.V. – Studies on the Primary Production in the Indian Seas:- – 1974 – Independent Research.

The Thesis gives a comprehensive account on primary production and related environmental factors of the Indian Seas. It also contains an account of the potential fishery resources of the West and East Coasts of India and the Indian Ocean in general. Details of intercalibration trials for standardization of carbon isotope stock solution have been discussed in detail in the methodology.

It has been found that the shallow inshore waters are more productive than the offshore waters. The annual production on the West Coast for the inshore waters is computed at 50 million tonnes of Carbon and 30 million tonnes for the outer shelf. On the East Coast for the entire shelf it is 25 million tonnes of Carbon.

For the whole Indian Ocean the annual production is computed at 3.9 x $10^9$ tonnes of Carbon for an area of 51 million sq.km.

The potential yield of both demersal and pelagic fisheries is computed at 2.4 million tonnes for both the coasts and for the Indian Ocean as a whole it is about 11 million tonnes of fish. The factors controlling the production have also been discussed.

## M.S.5. VARGHESE P. OOMMEN – The Digestive systems in Cephelopods: Food and Feeding Organs of Certain Coleoids – 1976 – Dr. P. Dinamani.

Three species of cephalopod molluscs collected from the waters in and around Cochin area of the Arabian Sea of South India formed the subject of the study The species are *Loligo duvauceli, Sepia aculeata* and *Sepiella inermis.* Their food and feeding habits, morphology and histology of the gut as well as the physiology of digestion have been described.

The feeding organs like the tentacles, the arms, the jaws and the buccal mass of these three species are suitably adapted for the active predatory mode of life.

The stomach is well developed to triturate the food received along with digestive enzymes secreted by the midgut glands. The caecum sorts out digestible particles and facilitates absorption. Digestion is also carried out in the intestine.

Histologically the alimentary canal is adapted for the type of food ingested; cilia and mucus cells are the dominant features. The well developed muscle layers, the closing mechanism of the caecum and the ciliated leaflets are all adapted for a quick and efficient digestive process.

Physiological study was an attempt to estimate amylase, lipase and protease in the various regions of the alimentary canal, i.e. stomach, caecum, intestine including rectum, liver and pancreas. All the three enzymes were found from almost all the regions of the alimentary canal.

All the three species were carnivorous forms feeding mainly on fishes, crustaceans and squids. Cannibalistic behaviour has been observed in *L. duvauceli.*

An attempt has been made to present useful informations regarding the biomass as well as the list of the species known to occur in the Arabian Sea.

## M.S.6. SUNNY, K.G.- Studies on the Morphology, Biology and Development of the Mullets of Kerala – 1976 – Dr. C.T. Samuel.

The mullets belong to the family Mugilidae of the Order Mugiliformis. They constitute a good estuarine fishery in many tropical and sub-tropical countries. In India, the mullets are distributed in the estuaries, backwaters and the inshore waters of the sea. Mullets have long been regarded as one of the most suitable groups of fishes for largescale brackish water farming.

*Mugil cephalus* Linnaeus enjoys a wide distribution in the tropics and sub-tropics. This species is economically more important than the remaining species. On account of these factors *M. cephalus* is the best studied species of the Mugilidae.

Hence, any account of the biology of the species belonging to this family will be heavily biased towards *M. cephalus*. Although a number of accounts on particular aspects of the biology of the Indian mullets are available, the biology of mullets of Kerala is left out. Studies on the development of Indian mullets also have been limited to a few species.

The present study attempts to give a comparative account of some of the morphological features (those, for which detailed descriptions are not available) of the four most common species of mullets of Kerala. Studies on the biology and development of two of these species are also included in the thesis. The species selected for the study were *M. macrolepis* Smith ( = Liza macrolepis), *M. parsia* Hamilton ( = Liza parsia); *M. cephalus* Linnaeus and *M. cunnesius* Valenciennes.

Material for the study was collected from two stations in the Vembanad Lake (one at Munambam and the other at Fort Cochin) and also from the fish farm at Narakkal. Fish specimens for the study of the morphology were collected, apart from the above-mentioned centres, from the Ernakulam fish market also. Samples collected from these centres at regular monthly intervals from June 1971 to May 1973 were used to study the biology of the fish.

### MORPHOLOGY

A comparative study of the skeletal, respiratory, circulatory, excretory and reproductive systems of *M. macrolepis, M. parsia, M. cephalus and M. cunnesius* was undertaken, and the interspecific variations observed are described in the thesis.

The skeletal system was studied from alizarin preparations. Bones were disarticulated for detailed study, after the specimens were partly boiled to loosen the tissues and the bones. Further, fresh specimens were dissected to observe the relationship of the soft parts of the body to the various bones. A number of bones showed no difference in shape and development in the four species of mullets studied, and a good number of them, which differed in each species have been observed.

Dissections were made on fresh and preserved specimens for studying the respiratory, circulatory, excretory and reproductive systems. The structural homogeneity prevailing in Mugilidae could be easily made out from the striking similarity exhibited by these systems.

### BIOLOGY

The length-weight relationship of *M. macrolepis* and *M. cunnesius* was determined by using the equation $W = aL^b$. There was no marked difference in the length-weight relationship of the fish in the male, female and indeterminant (fish too small to be sexually differentiated) groups.

The food of *M. macrolepis* and *M. cunnesius* was studied by examining the gut contents. The gut was fixed in 5% formaldehyde. The extent of the feed was determined by the degree of distension of the stomach and the quantity of food it contained. Pearse's method of estimation by the eye was found to be the only practicable means of determining the quantitative composition of the gut contents. It was observed that the early stages of both the species fed on phyto and zooplankton, while the juveniles and adults are essentially bottom feeders, the food of these constituted filamentous and blue-green algae, detritus, nematodes, polychaetes and amphipods.

The maturation and spawning of *M. macrolepis* and *M. cunnesius* were studied by defining the stages of sexual maturity and following them at monthly intervals and also with the aid of ova-diameter measurements, following the method introduced by Thomson and developed by Clark. It has been observed that *M. macrolepis* (individual fish) spawns only once during a short period in an year. The breeding season of the fish is during May to January, with a peak during June and July. The breeding season of *M. cunneslus* was observed to be during the period May to September.

The fecundity of *M. macrolepis* and *M. cunnesius* was ascertained by counting the number of ova. The fecundity of *M.macrolepis* varies between 1,43,630 to 6,42,100 ova and that of *M.cunnesius* varies between 17,210 and 72,320.

### DEVELOPMENT

The early development of *M.macrolepis* and *M.cunnesius* was studied by fertilising the eggs in the laboratory and examining the developing eggs and larvae under a microscope. Gravid females and mature males were collected from catches of the Chinese dip nets operating in Munambam and these breeders were stocked in cement tanks containing water having a salinity of 31%. and temperature ranging from 27 to 30.5°C. The gravid female fish was given two doses of 2 - 3 pituitary glands as aqueous extract, while the male fish was given only one dose of the extract. The pituitary glands were collected from fish belonging to the same species, i.e., the breeders of *M. macrolepis* received extracts of pituitary glands from *M. macrolepis* itself. When egg binding was noticed, the fish was hand-stripped into clean enamel trays. Milt from the males was pressed out and washed on to the eggs. The eggs were spread out by slight shaking of the trays. The trays were kept undisturbed for about 15 minutes, so that fertilisation could take place. After this, the trays were filledwith clean filtered brackish water and the eggs were allowed to stand undisturbed. The temperature and salinity of the water in the trays were recorded. Samples of 5 - 10 developing eggs were fixed in 5% formaldehyde for later detailed examination. The developing eggs were observed under the microscope in the live stage also. Samples were taken every ten minutes during the first six hours of the experiment. Later, two samples were taken every hour at regular intervals. Samples of the hatched and developing larvae were taken at intervals of one hour. These observations were continued until there was complete mortality of the developing larvae. It has been observed that under the same conditions of salinity and temperature, the time taken for the development of the eggs and larvae of *M. macrolepis* and *M. cunnesius* varies considerably.

## M.S.7. VARGHESE, P.P. – Studies on the Biology, Morphology, and Development of Cichlidae (Pisces) of Kerala, India – 1976 – Dr. C.T. Samuel.

In India the family Cichlidae (Pisces) is represented by three endemic species, *Etroplus suratensis* Bloch (Pearl-spot), *Etroplus maculatus* Bloch (Orange-chromide), and *Etroplus canarensis* Bloch. A fourth species, now common in the coastal plains and fresh waters of the east and west coasts of India is *Tilapia mossambica* Peters (Java Tilapia), an exotic species introduced into India, in 1952. My investigation was restricted to *Etroplus suratensis, Etroplus maculatus,* and *Tilapia mossambica*, which are widely distributed in Kerala. *Etroplus canarensis* is not seen in the waters of Kerala.

The following aspects were investigated:

**(1) Food and feeding habits:**

Composition of the natural diet of these fishes is reported, based on the analyses of the gut contents collected during one year. Collections were made from Narakkal Fish Farm Cochin. Observations on the feeding habits were made at the same locality. A semiannual change in the composition of the food consumed is noted. Since *Etroplussuratensis* and *Tilapia mossambica* are valuable fishes for culture, a comparative study of the diet and dietary habits of these fishes is very important for effective management of their culture.

**(2) Alimentary canal:**

Morphological details and structural peculiarities of the alimentary canal and organs associated with feeding were investigated. It is observed that the alimentation of the cichlidifishes is modified to suit the specific feeding habits. A constant linear relationship is noted between the total length of the fish and its intenstine in the three species of cichlids.

**(3) Osteology:**

A comparative study of the skull and cranium (except *Etroplus suratensis)*, and the vertebral column of these three species of fishes was made. No interspecific variation between the two species of *Etroplus* was observed, except for the difference in size of the various components of the axial and appendicular skeletons. Since the two species of *Etroplus* are endemic to the Indian Subcontinent, this osteological study has revealed their relationships to, and differences from, the African cichlid species, *Tilapia mossambica*.

**(4) Cranial muscles:**

Cranial muscles of fishes constitute very complex and intricate systems. The origin, attachment, and working of the cranial muscles of these three species of fishes are described in detail. Study of the structure of the jaw muscles has contributed in detail. Study of the structure of the jaw muscles has contributed to an understanding of the functional design of protrusible jaws. The arrangement and attachment of the different cranial muscles are in conformity with the highly compressed nature of the body. Interspecific variation of all the systems studied in these cichlids is displayed in a higher degree in the musculature. This is clearly evident in the case of *E. suratensis* and *E. maculatus*, with regard to some sub-divisions of the different muscles which are either altogether absent, or reduced. or rather degenerated in size. Other differences in the morphological details of the cranial muscles of these cichlids are very few. As cichlid fishes are commonly used as subjects of behavioural studies, a knowledge of the structure and relationship of the cranial muscles of these fishes is very helpful. It is equally important in the study of their evolutionary tendencies.

**(5) Larval development of Etroplus maculatus:**

Eggs of *Etroplus maculatus* collected from Narakkal Fish Farm were incubated in the laboratory and larval developmental stages were studied. Morphological description of the developmental stages upto postlarva is given.

The peculiar method of laying the eggs and an account of the parental care are also made.

A short, critical analysis of the evolution of the strange breeding habits of cichlid fishes is presented.

## M.S.8. GOPALAKRISHNA KURUP, P. – Studies on the Physical Aspects of the Mud Banks along Kerala Coast with special reference to the Purakad Mud Bank – 1976 – Dr. V.V.R. Varadachari

The patchs of clam, turbid water with high load of suspended sediment, appearing close to the shore along the Kerala coast during the south-west monsoon season, are known as the mud banks. The mud bank formations not only influence the socio-economic life of the fishermen community of Kerala, by way of providing them with calm fishing groups during the monsoon season, when the sea is otherwise rough and inaccessible for their frail crafts, but also influence the shoreline changes along the coast. Acting as dampers to waves, the mud banks protect portions of the beach from erosion and also help in trapping alongshore drifts from either side, facilitating growth of the adjoining beach.

Results of the investigations on the seasonal and spatial variations of hydrographic parameters suspensates, their flocculation and settlement, physical properties of the bottom sediments, waves and currents in the region of the mud banks along Kerala coast have been presented. Detailed investigations have been carried out in the region adjoining the Purakad mud bank. The studies show that the formation of the mud banks is closely related to the activity of higher period waves and their refraction pattern and also the fineness of the bottom sediments in the near-shore regions of the Kerala coast adjacent to the backwater system. The location of the mud bank is decided by the location of the zone of converging littoral currents and the associated offshore flow which carries large quantity of suspended sediments and low salinity water from the near-shore regions. Mud in suspension is supplied continuously to the mud bank from both the nearshore and offshore directions, the former by rip flows and the latter as bed-load transport by waves. This supply compensates the quantity of mud settled and also that taken out of the mud bank by currents. The decrease in wave activity and the enhanced settlement lead to disappearance of the mud banks during post-monsoon season. The studies show that the movement of the mud bank is related to the direction of wave approach and the relative strength of the littoral currents on either side of the mud bank.

## M.S.9. MADHUPRATHAP, M. – Studies on ecology of zooplankton of Cochin backwaters 1977 – Dr. T.S.S. RAO

Interactions of the environment and zooplankton organisms inhabiting the Cochin backwaters, a tropical estuarine system, was studied based on the data collected during the years 1971-72. Hydrographic data and plankton collections were taken from stations fixed in the estuary.

Fluctuations in the estuary are of extreme nature especially with regard to salinity. The backwaters remain saline only for a period of six months, or so, which represents the relatively more stable period in the estuary. Salinity values are high throughout the system during this period, with a gradient from head to mouth.

Monsoon have pronounched influence on the ecology of the system bringing about a total change in the environment and fauna. Salinity values fell to zero or near zero values thoughout the estuary except at the mouth.

Water column is well mixed and more or less vertically homogeneous during the peak salinity period. It is stratified only in the post-monsoon and early pre-monsoon months. Considering the importance of the effects of the monsoons in the system, Cochin backwaters may be called as a "tropical monsoonal estuary".

Displacement volume, total numbers and numerical abundance of most groups and species of zooplankton showed significant higher abundance during pre-monsoorn period. Crustacea and among them Copepoda contributed to the bulk of the biomass and total numbers. Seventy six species, of them 49 from copepoda, were identified from the estuary.

Carnivores (of the first order) such as hydromedusae, ctenophora and chaetognatha were more numerous during the saline period when there was a higher standing stock of other zooplankton. Surpirsingly, cladocerans were more common during low salinity period.

Copepod species of the saline period consisted of estuarine, estuarine and marine, euryhaline marine species and accidental immigrants. Family Acartiidae comprising 10 species formed the majority of copepods in the estuary. Common high saline species occurred at the lower reaches during post-monsoon months and penetrated further up the estuary alongwith the incursion of salinity. They were washed out in the monsoonal efflux. This was the general pattern of distribution showed by high saline species of other groups too.

Among all the groups only a single copepod species, *Acartiella gravelyi*, successfully thrived in the estuary during low salinity regime. Other low salie species occurred in small numbers only.

Decapod larvae stood next to copepoda in the order of abundance. Larvae and postlarvae of various commercially important decapods were identified in the collections. The estuary forms the breeding and nursery ground for them and other fishes as could be recognised from the abundance of invertebrate larvae, fish eggs and fish larvae.

Diel variations in total numbers were not significant for many groups and species. The tendency was for part of the population to spread upward rather than a complete movement. Indications of presence of low salinity water at the surface inhibiting vertical migration was observed for high saline species.

Although tidal exchanges is a key factor in the dyynamics of the estuary, most species did not show significant variations with tides in numerical abundance at the mouth. Species appear to develop behavioural mechanisms in response to tidal changes which keep it in the water of same salinity through out the tidal cycle by having some kind of a biological clock or signal.

The average zooplankton production in the estuary was estimated to be 31.8 mg dry weight/cubic meter/day. The production during high saline period is much higher compared with low saline period.

The 'successful species' in the estuary during the saline period exhibited a wide range of salinity tolerance.

Repopulation of the intermonsoon waters of the backwaters after monsoonal wash out seems to be effected in two ways. True estuarine species may have quiescent stages to tide over adverse environmental conditions and become active when salinity reaches appropriate threshold or it may happen through recruitment from coastal waters.

The pattern of succession gathered from the dominance broadly outlined three seres. They consisted of high saline species, low saline species and species preferring medium salinities.

Bioceonosis of the Cochin backwater system can ben recognised as a physically controlled community. Species diversity is low particularly during low saline period as the stress component increases.

An analysis of the species associations between the common species of copeopods that consistently appeared in the collections also distinguish the three serial stages. A high degree of correlation was exhibited by high saline species. It is suggested that the peculiarities of this system allow them to survive as competitors, since it is conceivable for the competing species to expand their overlapping niches in space with time because of the facility provided by salinity intrusion. The elimination is automatically effected by the monsoonal effluxes before the severity of the competition leads to it.

## M.S.10. MOHAMED SALIH, K.V. – Studies on the backwater clam, Meretrix Casta (Chemnitz) off Cochin Barmouth – 1977 – Dr. C.V. Kurian.

Studies on the biology of *Meretrix casta* (Chemnitz) was under taken based on regular collections during 1971-1974 from the clam bed off Cochin barmouth. The relation between different dimensions of the shell of clam to length and total weight growth in three dimensions, seasonal variations in numerical abundance and biomass of the population, seasonal gonadal changes and spawning, biochemical composition, salinity tolerance, oxygen consumption are dealt in this study. Hydrological data and nature of substratum were also recorded.

Analysis of data showed that numerical density of the clam in the bed off Cochin barmouth is at its lowest during active S.W. monsoon. Increase in the number occurred immediately after S.W. monsoon owing to the recruitment of the young clams. Highest biomass observed was 10240.98 gm/$m^2$ in April 1972.

*M. casta* prefers a substratum consisting of fine sand mixed with a small percentage of silt and mud. Salinity in the clam bed varied between 2.30% to 35.38% and temperature varied between 21.13° C to 30.23° C.

Biometric relations between length to height, depth and total weight have been studied using least squares. Similarity in growth patterns were observed among the different dimensions. Actual growth rates coincided with values computed with von Bertalaniffys growth equation. Sexes separate in *M.casta*. Maturity of gonads are inferred from variations in percentage edibility and cytological preparations. Gametes start development during second half of January, reached maturity from June to second half of July and spawning started by the middle of August and continued till the end of October.

Salinity has been observed to have an important role in the development of gonads and spawning. Increase in salinity has proved to initiate gonadal activity and the activity increases steadily when the salinity increases.

Seasonal variations in water content, glycogen, protein, fat and calorific value in the body entire and in selected component parts (gonad and adductor muscle) were studied. It was observed that water content in gonad was higher throughout the year than that in body entire. Glycogen in the gonad showed in inverse relationship with water content. Protein content of the gonads was found to be highest when they were gravid, while glycogen and fat dominated in immature gonads. It was found that Calorific value increased in post-monsoon period owing to the increase in glycogen and protein content. During this period fat showed a decrease.

Variations in the water content of the adductor muscle was found to be similar to that in the body entire and in the gonad. Glycogen and protein showed a steady fall during the pre-monsoon period and an equally steady rise during the post-monsoon period. The concentration of inorganic constituents like ash, iron, copper, calcium and magnesium in the entire body of *M.casta* with respect to seasons was studied. Ash value was lowest (5.76%) in June and highest (6.35%) in November. An inverse relation between iron content and salinity of the ambient water was noticed. The trend of concentration of copper was similar to that of iron, showing a negative correlation with salinity. Absolute values of magnesium were less than those of calcium throughout the year. The distribution of calcium and magnesium in tissues of *M. casta* showed an opposite trend to copper and iron.

Experiments on salinity tolerance were conducted with 3 different size groups: 8-15 mm, 20-30 mm, 32-38 mm (length) in different salinity media ranging from 0% - 40% at 5% intervals. Lethal salinities of all size groups were studied which revealed that the small clams were capable of withstanding a greater variation in salinity than the larger ones.

The total and weight specific oxygen consumption were size dependant in all the eight concentrations ranging from 5% S to 40% S at 5% S intervals. The values of b varied from one salinity to another which showed that the extent of dependance of metabolism on size was different in different salinity media. The metabolic rate varied from less than proportional to surface to intermediate between proportionally to weight and surface area. The b values obtained for *M. casta* in the present study in different salinities were well within the range of b values reported for bivalves by earlier workers.

### M.S.11. CHERIAN, C.J. – Studies on some boring and fouling crustaceans – 1977 – Dr. C.V. Kurian.

Eco-physiological studies were made on three species of isopods – *Sphaeroma annandalei, Cirolana fluviatilis* and *C. Willeyi* found associated with underwater timber structures in Cochin Harbour region, South West Coast of India. *S. annandalei* is one of the most destructive wood-borers in this region.

*C. fluviatilis* and *C. Willeyi* are two free living foulers. Studies on their feeding habits have shown that *C. fluviatilis* and *C. willeyi* are carnivorous and predators of borers and foulers and hence they can check the organisms which attack submerged wood.

Hydrographical studies showed that salinity was the master factor affecting life in the habitat of these isopods, the temperature variations being not much significant. Inspite of the wide seasonal variations in salinity these isopods occurred throughout the year in the Cochin harbour area.

Laboratory experiments on salinity tolerance supplemented by field observations revealed that these isopods were essentially euryhaline. But the ranges of salinity variations tolerated by each species varied depending on the salinity to which it was acclimated.

Three series of salinity tolerance experiments were carried out using animals acclimated in low (1‰), medium (17‰) and high (33‰) salinities representing the three seasonal salinities in the habitat.

Acclimation to low salinities tended to shift the lower lethal limit downward and acclimation to high salinities tended to shift the upper limit upward in the case of *S. annandalei*. In *Cirolana* spp. even though there was a shift in the lower limits down-ward in accordance with the decrease in the acclimation salinity, the upper limits did not show a corresponding increase with the increase in the salinity of the acclimation medium.

The studies showed that *S. annandalei* was essentially a brackish water species which preferred lower salinities and the degree of euryhalinity exhibited by it was less compared to the other two species. *C. willeyi* was more inclined to low salinities and was capable of surviving even in distrilled water for several days. Of the three species, *C. fluviatilis* was the most tolerant to variations in salinity.

Studies on the oxygen consumption of the three species showed that the regression coefficients of $O_2$ uptake against body weight significantly differed on several occasions from the general value of 0.67 reported for crustaceans. The present values in the three acclimation salinities were generally low compared to those reported for other crustaceans.

The metabolic rates of *S. annandalei, C. fluviatilis* and *C. willeyi* were mostly high compared to those reported for some other isopods. The seasonal variations in the average metobolic rates of *S. annandalei* being not so prominent it was assumed that the animal was not under considerable stress in any of the three seasons. The metabolic rates of *Cirolana* spp. were higher than those of *S. annandalei* and this differences was attributed to the differences in the habits of the three species. In *S. annandalei* the metabolic rates of smaller animals varied widely in the three acclimation salinities. But in *Cirolana* spp. both the big sized and small sized animals showed considerable variations in the metabolic rate.

All the three species respired at the minimum rates in the medium salinity (17‰) and this suggests that they were genetically better adjusted to it. Oxygen uptake of the three species has been studied in relation to direct changes in salinity also. In this series, animals were directly transferred from the acclimation salinities to lower and higher salinities. In general the respiratory rate of *S. annandalei* and *C. fluviatilis* decreased in supranormal salinities, while it increased both in supra and subnormal salinities when they were subjected to salinity changes. The variations in the respiratory rates showed that in all the three species, the small animals were more affected by salinity stress than the large animals.

*S. annandalei* is a 'regulator' in which the respiratory rate is constant up to $PO_2$ 100 mm Hg in the acclimation salinities. The critical $O_2$ tension shifts to 120 mm Hg when the animal is subjected to salinity changes. It even becomes a 'conformer' in which $O_2$ uptake is dependent on $O_2$ tension, when transferred from the high salinity to the medium salinity. *C. fluviatilis* and *C. willeyi* are 'conformers' and their respiratory rates decreases with declining $O_2$ tension. These differences in the oxygen consumption in declining $O_2$ tension can be attributed to the differences in the habits of the three species.

The present studies revealed that all the three isopods can survive in very low $O_2$ tensions. The lower lethal levels of oxygen concentration for each species in various salinities have been found out. It is noticed that sublethal salinity variations do not show any significant influence on the lethal $PO_2$ of these species. The lethal $PO_2$ does not show any weight dependence also.

## M.S.12. JACOB GEORGE – Studies on Planktonic Ostracods of the Northern Indian Ocean – 1977 – Dr. C.V. Kurian.

The planktonic ostracods form one of the most important groups in tropical zooplankton. One of the main objectives of the International Indian Ocean Expedition has been the study of the qualitative and quantitative distribution of planktonic organisms in the Indian Ocean and the present study is significant as Ostracods constitute a large portion of the zooplankton samples. The nature of ostracod production in the area directly reflects on the total productivity as they play an important role in the rapid recycling of organic substances and the distribution studies would help in evaluating their adaptation to physico-chemical and biological environment and to know about their community structure and species diversity.

Seven hundred and twelve samples collected from the Northern Indian Ocean forms the basis for the present study. Besides dealing with the distribution pattern of the various species short notes on the morphological peculiarities of the specimens in the collections are also given. The material dealt with was collected during 110 E (1960-1965) from 200 m to 0 m using Indian Ocean standard net. Thirty two species have been identified from the samples, their number and locations are given, two of them belonging to cypridinidae and the rest to Halocyprididae. Systematics of the species has been discussed giving importance to diagnostic features; distribution maps of the species are given. Arabian sea was found to have a rich ostracod fauna compared to Bay of Bengal or equatorial region of the Indian Ocean. Based on their distribution ostracods are categorised into four groups - widely distributed, equatorial, restricted to Arabian Sea and patchy. The reduction in the number of ostracod species in the Red sea is attributed to the hot saline waters of the area. *Cypridina acuminata* is restricted to the area off Bombay, *Cypridina dentata* is found to be the most abundant species in the Arabian Sea. Considering the Northern Indian Ocean as a whole, *Euconchoecia aculeata* is the most frequent and dominant species. Except *paraconchoecia decipiens, Orthoconchoecia striola, Bathyconchoecia deeveyae* and *B. angeli*, all other species collected are common to Atlantic and Pacific Oceans. The abundance in the distribution of ostracods correspond to that of other crustaceans and also to the areas of high productivity. Statistical analysis of the data shows significant seasonal variations for *Cypridina dentata, Euconchoecia aculeata, Paraconchoecia procera, P. decipiens* and *Conchoecetta giesbrechti* and day and night variations for *Paraconchoecia procera, P. decipiens* and *Conchoecetta giesbrechti* and day and night variations for *Paraconchoecia procera, P. decipiens, Conchoecetta giesbrechti* and *Spinoecia porrecta*. Breeding, as deduced from the occurrence of juveniles and ripe females in the samples is found to be continuous.

## M.S.13. KURUVILA MATHEW – Studies on a sea Anemone, Anthopleura Nigrescens (Verrill) from the South West Coast of India – 1978 – Dr. C.V. Kurian

*Anthopleura nigrescens* (Verrill) is an intertidal sea anemone found attached to hard substrata like rocks, molluscan shells etc. The species is found abundently in the Cochin area where sea walls have been constructed to prevent sea errosion. The study on this anemone includes important aspects on the morphology, bionomics and physiology.

Hydrographical studies of the area of investigation showed that *A. nigrescens* is capable of surviving high fluctuations in salinity and depletion of dissolved oxygen in the field. Laboratory studies on salinity tolerence showed that this anemone is one of the most euryhaline species of actinians tolerating low salinities upto 3%.

The distribution of *A. nigrescens* with reference to their vertical zonation of the intertidal region of the Cochin area is also discussed.

Analysis of the food contents in the gastric cavity of *A. nigrescens* from the field showed that this anemone is carnivorous and essentially a plankton feeder. Laboratory experiments on feeding habits was also made to study the relation between salinity and feeding, reproduction and feeding etc. and the results are discussed. It was found that this anemone neither intake food nor show any response to it in very low salinities. Also they do not show any response to food during the time of/ a sexual reproduction.

Studies on digestion showed that mesenterial filaments are the chief source of supply of enzymes. Proteolytic and lipolytic activities were seen in the mesenterial filament, stomodaeum and gastric fluid. Amylolytic activity was very little and is restricted to the mesenterial filaments.

Experiments on oxygen consumption of the anemone showed that the uptake of oxygen per unit time increased with increasing body weight. The regression value of metabolic rate has been discussed.

Studies on the effect of desiccation of *A. nigrescens* showed that exposure to air for 5 to 6 hrs under laboratory conditions was lethal to this species. The amount of water loss during each hour of exposure has been discussed.

This anemone is capable of asexual reproduction and regeneration of lost parts. Investigations based on laboratory experiments supplemented by field data on the above aspects have also been discussed in detail. It was observed that asexual reproduction is influenced by salinity changes.

## M.S.14. GOPINATHA MENON, N.-Studies on the Biology and Fishery of the Giant Marine Catfish, Tachysurus Thalassinus (Ruppell)–1979 Dr. P.V. Ramachandran Nair.

This account deals with the biology and fishery of the giant marine catfish, *Tachysurus thalassinus* (Ruppell), commonly ocuurring in Palk Bay and the Gulf of Mannar, along with comparisons of allied species, viz. *T. dussumieri*, *T.*

*platystomus*, *T. caelatus* and *T. serratus* occassionally met with in the catches of Mandapam area. The investigations have been based on the samples collected over a period of two years from September 1969 to August 1971 from the landing centres of Mandapam, Pamban and Rameswaram (both Palk Bay and the Gulf of Mannar).

The systematic positin of the family Tachysuridae has been reviewed. Key to the identification of the Indian genera and species of tachysurids is given. Synonyms and the geographical distribution of five species of tachysurids occurring in Mandapam area have been dealt with in detail.

The age and growth of *T. thalassinus* were determined by a study of the length frequency distribution and from the growth checks in the hard skeletal parts like pectoral spines, vertebrae and opercular bones. Length frequency analysis of random samples of fish showed distinct modes. Invariably in all the types of bones studied and first transparant ring noticed was found to be formed when the fish attained 70 to 80 mm in total length. Such a 'larval ring' was seen in juveniles and '0' year old fishes. This 'larval ring' is formed when the juveniles escape from the parent's mouth to lead a free demersal life and the change of the habitat and food may be the causative factors for its formation. A comparative study of the age based on all the skeletal parts gave similar values and they closely agreed with the values obtained from length frequency studies. Further, six embroys were reared in the acquarium for a period of 13 months and their growth studied. The aquarium rearing also gave similar values in their growth rates as observed from other hard skeletal parts.

A study on the age composition of *T. thalassinus* in the commercial catches showed that the fishery at Mandapam was mainly composed of '0' and 1 year old fishes in both the years under observations.

The length-weight relationships of yolked larvae, immature females, mature females and males were worked out. Low values of relative condition factor observed in April to August among males and mature females, indicate the peak period of spawning.

The analysis of stomach contents showed that maximum percentage of fishes were well fed during the months of December to April-May and a high percentage were poorly fed during June-September period. The feeding intensity was low during the months of April to August, which coincides with the peak breeding season of this species. Qualitative analysis of stomach contents showed that this species mainly fed on the bottom epifauna, infauna and column fishes. Variation of food in relation to size showed that smaller fish fed on polychaetes, amphipods and smaller crustaceans andd their diet was restricted to a few items of bottom epifauna and infauna; while the larger 1 year and 2 year old fish fed on a variety of crustaceans and fishes both from the bottom ad column waters. Fishes of 3 years and above mainly fed upon fishes and larger crustaceans. A detailed study on the feeding of *T. thalassinus* in relation to sexual males completely refrain from taking any food during the period of gestation. The analysis of stomach contents of yolked larvae collected from the mouth of gestating males showed that they fed on small planktonic organisms like copepods, nauplii, zoea and other crustacean larvae. It is possible that, while the parent fish move in the water, the organisms present in the respiratory incurrent of the parent may be injusted by the larvae as they themselves utilise the same incurrent for their respiration.

Three different categories of ova are noticed in the mature ovary of *T. thalassinus*. The present study shows that the fish has only one batch of mature ova and after spawning the ovary resembles stage III. In this species the spawning takes place only once a year. Even though the spawning period of the individual fish is short and once a year the population as a whole may breed over a long period of time with the peak breeding period from April to August. Females of *T. thalassinus* mature (stage III) at a size of 28 - 30 cm and males at 26 - 28 cm in total length. The males of this species first spawn when they are one year old, while females first spawn when they are two years old and thereafter every year of their life as in males. The maturity-maximum length relationship of *T. thalassinus* was found to be 0.3231 for males and 0.3419 for females. The fecundity varied from 31 ova in a fish of 378 mm snf 60 ova in a fish of 450 mm in total length.

High values of' gonado-somatic index were found in the months of April to August, which coincide with the peak breeding season of the species. The sex ratio of *T. thalassinus* has not shown much significant difference either in different age groups.

The early developmental stages and sequentil *ossification of T. thalassinus* are described.

Population studies of *T. thalassinus* have been based on statistical analysis of selected morphometric characters of fish samples drawn from Waltair, Tuticorin and Mandapam during 1970. The study shws that the samples from Mandapam show affinity to the samples of Waltair than to Tuticorin samples. Thus, the investigations reflect the possibility of the existence of different populations.

Two species of copepod parasites, *Caligus dakari* and *Hermilius pyriventris*, were recorded from the oral cavity and gill filaments, respectively of *T. thalassinus*. A species of the genus *Henneguya* was noticed in the sub-cutaneous muscle of the body of *T. thalassinus*.

Catfishes are caught from the coastal waters of India round the year by using different types of gears. Species composition of economically important tachysurids and their distribution and fishery along the Indian coasts are also described.

## M.S.15. KUTTY AMMA, V.J.–Studies on the Common Penaeid prawns of the Kerala Coast–1979–Dr. C.V. Kurian

Research investigations were carried out on the common penaeid prawns of the Kerala Coast. The thesis is presented in three parts. The first part deals with the prawns and prawn fisheries of Cochin backwaters and Kayamkulam lake. The second part deals with the tolerance of prawns to salinity and temperature and the effect of salinity on growth. The third part deals with the oxygen consumption of *Metapenaeus dobsoni*.

The most common species of penaeid prawns that occur in the Cochin backwaters and Kayamkulam lake are *Penaeus indicus*, *Metapenaeus dobsoni*, and *M. monoceros*. It was obvious from the monthly observations carried out during 1976 – 1977 that there was definite seasonal variations in the larval recruitment into the two estuaries. In the Kayamkulam backwaters there was only one peak of larval occurrence and that was from September to January. In the Cochin backwaters there were two peaks of occurrence for the prawn larvae, one from September to December and the other from February to May. The total number of larvae obtained in a unit area in an year in the Kayamkulam lake was more than that of the Cochin backwaters. Postlarvae and juveniles of *P. indicus* were predominant in the Kayamkulam lake and that of *M. dobsoni* dominated in the Cochin backwaters. When the size variations of prawns caught in the three common nets operated in the lakes viz. cast nets, stake nets and chinese dip nets were compared, it was found that those obtained in the cast nets were larger, whereas the catches in the stake nets were smaller. Both large and small prawns were obtained in the chinese dip net. The abundance and occurrence of prawns in both the estuaries were influenced mainly by salinity and to a lesser extent by temperature. During the monsoon season the catch was poor and during postmonsoon and premunsoon periods there was good catch.

Laboratory experiments on salinity tolerance revealed that these prawns are essentially euryhaline and they could tolerate wide ranges of salinity from 3% to 43%. When the three species were compared, the differences found in their tolerance capacity in varying salinities from 0 to 50% were not significant.

Experiments in the laboratory on the tolerance of the three species of prawns at elevated temperatures have shown that both the postlarvae and juveniles could survive in temperatures upto 36°C. *M. dobsoni* showed more tolerance than the other two species whereas *M. monoceros* showed the least tolerance. The upper lethel temperature slightly varied in different species as well as for both postlarvae and juveniles.

Both postlarvae and juveniles of *P. indicus, M. dobsoni* and *M. monoceros* were used for laboratory experiments to study the effects of salinity on growth. The results of the study for about one month showed that the growth of both postlarvae and juveniles of all the three species was affected by variations in salinity to a certain extent. The maximum growth of postlarvae of *P. indicus* occurred in 25% S and that of juveniles in 30% S. The maximum growth of postlarvae of *M. dobsoni* and *M. monoceros* was noticed in 20% S and that of the juveniles of both the species in 25% S. *P. indicus* showed the highest growth rate whereas *M. dobsoni* showed the minimum growth rate.

The oxygen consumption in relation to salinity and oxygen concentration was investigated in the prawn *M. dobsoni*. It was found that the regrassion coefficient of oxygen consumption against body weight was not significantly varied in different salinity media. An increase in the oxygen uptake had been observed with a decrease in the salinity of the medium below that of the acclimation salinity. The rate of oxygen uptake per hour under falling oxygen tension in different salinity media showed variations. The tolerance capacity to low oxygen content decreased as the animal become larger.

## M.S.16. REMANI, K.N.–Studies on the effect of Pollution with Special Reference to benthos in the Cochin back waters.–1979–Dr. R.V. Unnithan.

Effect of organic and industrial pollution at three localities in the Cochin back waters were studied from 1974–1977. Seawage pollution was studied from seven stations around Willington Island (1974–75). and pollution due to retting was studied at Vaduthala (1975–76). Industrial pollution of upper reaches was studied during 1976–77. Sampling was done along the gradient of stress covering affected, unaffected and recovering zones in all cases.

Temperature salinity, dissolved oxygen, $BOD_5$ total sulphides, nature including composition of sediments and benthos of organically polluted areas were studied. Assessment of industrial pollution was based on water quality, nature and composition of sediments, and trace metal contents. The study was mainly concentrated on the effects of organic pollution (Sewage discharge and retting) on benthos and environment of the study area. Data on industrial pollution was used to augment the other sets of data so as to arrive at an overall assessment of pollution of this water body.

In the benthic study the main factors considered are ranges of environmental parameters within which the benthic animal species occur, frequency of their occurrence and type of the substratum. Observations show that ecological groups of organisms may be distinguished on the basis of their reactions to pollution. Accordingly in the present study the benthic animals are separated into three groups; a) Species which favour pollution with their maximum occurrence in polluted areas. b) Indifferent species which show an incomplete affinity to polluted habitat though they are not totally absent in the polluted areas and c) Species - which avoid pollution which are more or less absent from polluted areas.

In the retting grounds the polychaete *paraheteromastustenuis* (capitellidae) limivorous in feeding habit is proposed as an indicator species with a high population density in polluted stations. *Prionospio polybranchiata* (spionidae) which is a selective deposit feeder is proposed as an indicator of pollution in the sewage polluted area. It may be that the difference in the local abiotic factors of the two water bodies vary considerably so as to choose their own indicator species at least in the macroenvironment. In the industrial effluent discharging area the pollution is mainly from inorganic source and the chain of factories are solely responsible. A comparative study of the above three areas of Cochin back waters show that pollution is considerable in the back waters.

## M.S.17. GOPALAKRISHNA PILLAI, N.–Microbenthos of a Tropical Estuary – 1979 – Dr. R. Damodaran.

An investigation on the macrobenthos of the Cochin Estuary on the South West Coast of India was carried out during March 1974 to March 1976 from five selected stations, almost equidistant from one another and having depths ranging from 1.5 to 4 m. The samplings were done during high tide at fortnightly intervals in the first year and at monthly intervals in the second year. Along with the bottom fauna water samples for hydrographical studies were taken from each station. Sediment samples were also collected from each station in order to study the physico-chemical nature of the bottom.

A study of the hydrographical conditions of the region showed that there was marked seasonal variation in the salinity. The pre-monsoon period is dry with less rain fall and the maximum salinity (33.13%) was observed during this period. The South West Monsoon is characterized by heavy rainfall and low salinity values, both in the surface and bottom waters. During the peak of the monsoon season, the estuary becomes completely filled with fresh water.

The seasonal variations were well reflected in the temperature pattern also. For the estuarine system as a whole, the pattern of variation of temperature was bimodal, and the lowest temperature of surface water and bottom sediment recorded were 25.1 and 25.0°C respectively during monsoon period and the highest temperature were 32.5 and 32.2°C, respectively during the pre-monsoon period.

Annual variations of both surface and bottom water dissolved oxygen content were not considerable, except at station I, near the barmouth, where the recorded values were as low as 2.42 ml/L during the South West Monsoon and this is attributed to the influence of upwelled water. But in all the other stations higher values of dissolved oxygen were found at surface and bottom waters during the monsoon period.

The nature of the bottom deposit showed that the composition of sediment varies markedly from station to station. Based on the investigation, the region under study was differentiated into four sedimentological divisions: (1) area covered by clayey silt with very little sand - stations I and II; (2) area with dominance of fine sand fraction - station III; (3) area covered by sand, silt and clay in more or less equal proportion - station IV; (4) area covered by sandy and mud - station V.

In general, the percentage of organic matter present in the estuarine sediment was high. The organic matter in the sediment varied from 2.86 to 5.02%, the maximum being in stations with high percentage of clay.

The important macrobenthic groups observed during the present investigations are Polychaeta, Crustacea and Mollusca. Altogether 91 taxa were identified. Among the various animal groups represented in the estuary, Polychaeta was the dominant one. Altogether 35 species of polychaetes belonging to 28 genera were identified. The largest number of polychaetes (5290/m$^2$) was recorded from station III in December 1975. Crustacean fauna was rich in terms of number and consisted of mainly amphipods, tanaids, isopods, cumaceans and brachyuran crabs. Amphipods were widely distributed and the maximum number of 6790/m$^2$ was recorded from station IV in December 1975. In the case of tanaids, a seasonal increase was noticed, the maximum recorded number being 10740/m$^2$ during October 1975. A total of 19 species of molluscs were collected. Of these, only two, *Modiolus undulatus* and *Nuculana mauritiana* were abundant and the maximum recorded numbers were 1059/m$^2$ and 39310/m$^2$ respectively.

From the study area as a whole, the average number of macrofauna recorded is 2332/m$^2$ and hence according to Thienemann's classification, Cochin Estuary may be described as euphotic.

The affinity analysis of the polychaete fauna showed that the station nearest to the barmouth exhibited the least stable community.

Species diversity of Polychaeta was low in stations located at the mouth of the estuary and a higher species diversity was observed in stations at the middle region of the estuary. It was also observed that the species diversity was greater during the high saline period (pre-monsoon) than during the low saline period (monsoon).

The observation on the benthic biomass in the study area as a whole showed a high benthic production. The average annual production (dry weight) during the first year of observation was 5.0881 g/m$^2$ and in the second year it was 7.4948 g/m$^2$. This increase in standing crop during the second year was due to the abundance of *Modiolus undulatus* and *Nuculana mauritiana*.

Correlation between the physico-chemical parameters and distribution and abundance of bottom fauna were tested by using Kendall's Rank Correlation Method. Of the various hydrographical parameters of the estuary studied, salinity is the most fluctuating factor, which had the greatest influence on the distribution and abundance of the bottom fauna. The poor faunal composition during the South West Monsoon (July-September) in all stations, particularly at stations I and II near the barmouth could only be due to the wide fluctuations in salinity. Temperature and dissolved oxygen do not show any significant effect on the faunal distribution in the area.

Animal-sediment relationship clearly indicated that a particular animal assemblage flourished only in a certain kind of substratum, where favourable conditions prevail. It was observed that higher biomass values were associated with a substratum having a higher percentage of fine sand with small percentage of silt, followed by silty bottom and the minimum biomass was found in clayey bottom.

Studies on the seasonal variation of macrobenethic components revealed that the largest benthic population occurred during the pre-and post-monsoon seasons and the minimum during South West Monsoon period (July-September). This decrease is attributed to the steep decline in salinity.

The maximum benthic production occurs in the pre-and post-monsoon period, when the primary production is also very high. It appears that there is a direct correlation between the benthic production and organic production in the Cochin Estuary.

As far as the benthic production is concerned, the area under observation is quite rich. In the study areas as a whole the production of macrobenthos, in terms of annual mean standing crop (wet weight) is 352.05 kg./ha and can be considered as rich in benthic production.

In the food web of the estuary polychates, amphipods, isopods, tanaids and cumaceans are important links; they feed on mud and organic matter and in turn are predated by bottom feeding fishes and prawns.

Out content analysis of commercially important penaeid prawns present in the estuary showed that all these species are omnivores and detritus feeders depending much on benthos.

The high benthic production suggests that the macro-benthos may be important as the food of bottom feeding forms especially prawns which form an important fishery in the Cochin Estuary.

In an attempt to identify the benthic fauna of the estuary, systematics of the polychaetes, the most dominant group in the area of investigation is given as part II of this thesis. A total of 30 species belonging to 25 genera are briefly described and among them 17 are new records from the Cochin Estuary.

## M.S.18. MOHAN, M.V.–Studies on the Teredinids of Cochin Harbour – 1979 – Dr. P.V. Cherian.

Teredinids (shipworms), a group of wood boring bivalves occurring in the Cochin Harbour region have been taken up for the eco-physiological studies. On the ecological part, the occurrence, abundance and seasonal intensity of the teredinids in relation to hydrographic conditions have been studied. On the physiological part, salinity tolerance and oxygen consumption of the most commonly ocurring shipworms, *Nausitora hedleyi* and *Teredo furcifera* have been investigated.

The hydrographic factors studied are temperature, salinity, dissolved oxygen, phosphate, nitrite, silicate and pH. The variation in temperature is found to be comparatively narrow. But seasonal variation in salinity, dissolved oxygen, phosphate, nitrite and silicate has been observed, with the highest values during the monsoon period. In the case of pH, the minimum value has been obtained during the low saline period and the maximum value, during the high saline period. Of the various hydrographic factors studied, salinity has been found to be the most important fluctuating environmental parameter influencing the life of organisms in the habitat.

Ecological studies, conducted by a system of short term and long term panel experiments have shown that *T. furcifera* and *N. hedleyi* are the most destructive shipworms in this region. The settlement of *T. furcifera* is strictly restricted to the high saline pre-monsoon months. The onset of the South West monsoon and the ensued sudden fall in salinity exterminate this stenohaline species. The settlement of *N. hedleyi* is confined mainly to the low saline period and it starts a short period after the commencement of the South West monsoon. The intensity of the settlement which goes on increasing throughout the low saline period declines and ultimately stops as marine conditions are established in the region. Almost at this time, the settlement of *T. furcifera* starts and the cycle of events is repeated.

Long term panel experiments reveal that the monthly pattern of settlement of shipworms is changed as the period of exposure of the test panel is increased. The number of *T. furcifera* and *N. hedleyi* in the test panel increases with increase in the duration of submergence. This is mainly due to the repeated settlement of waves of shipworm larvae and also due to the conditioning of the wood. But in certain periods, the intensity of teredinid attack does not increase with duration of exposure of the test panels for various reasons discussed in the text. Long term panel experiments also reveal that *T. furcifera* is a stenohaline species restricted to the period when marine conditions prevail whereas *N. hedleyi* is a euryhaline form which can withstand even the pre-monsoon high saline conditions as well as almost fresh water conditions of the monsoon period.

In addition to *T. furcifera* and *N. hedleyi*, three more species of shipworms, *Lyrodus pedicellatus, Bankia companellata* and *Nausitora dunlopei* have been collected, of which *N. dunlopei* is a new record from the West Coast of India.

The salinity tolerance studies have shown that *N. hedleyi* of small and large size groups acclimated in 5%o can be transferred abruptly to 20%oS and that the higher lethal salinity is 25%. However, smaller animals have shown comparatively better tolerance than larger ones. Small and large size groups of *N. hedleyi* acclimated in 20%S can be transferred to 5%S and the lower lethal salinity is 3%o. As in the former case, the smaller animals are found to be less sensitive to variations in salinity.

Gradual transfer of small and large size groups of *N. hedleyi* to lower and higher salinities extended the tolerance limit. Thus animals acclimated in 5% or 20% S are found to tolerate the entire salinity range tested (0.60 - 33.65% S). Here also, smaller animals exhibited better tolerance.

The studies, in general, have shown that in *N. hedleyi*, acclimation to lower and higher salinities shifts the lower lethal limit downwards and upper lethal limit upwards, respectively and that smaller animals are observed to tolerate variations in salinity better than larger ones. The investigations have also revealed that *N. hedleyi* is capable of tolerating a suddern salinity variation of 15% and if the change is gradual, it can tolerate a wide range of salinities. This gives a fair explanation for the observation that *N. hedleyi* occurs throughout the year in the Cochin Harbour region.

The 'b' values for *N. hedleyi* in 5% S and 20% S are 0.5959 and 0.6043, respectively and that for *T. furcifera* in 30% S is 0.5461. Comparison of the above values have shown that they are not statistically different, revealing the existence of similar metabolic types in the euryhaline *N. hedleyi* occurring mainly during the low saline period and in the stenohaline *T. furcifera* which is found only during the high saline period.

The rate of oxygen uptake for *N. hedleyi* in the two acclimation media is found to be comparable which suggests the capacity of the euryhaline species to adjust itself gradually to variations in salinity and carry on normal activities without making any appreciable change in the oxygen consumption rate. Comparison of the oxygen consumption rates of *N. hedleyi* with those of *T. furcifera* shows that the rates of the former are higher.

The 'b' values obtained for *N. hedleyi* acclimated in 5% S and experimented in different media varied from 0.5342 (in 20% S) to 0.9798 (in 25% S). Comparison of the regression coefficients shows that statistically significant differences exist between the 'b' values in salinities 0.60% and 25%, 3%, and 25%, 5% and 25%, 10% and 25%, 15% and 25% and 20% and 25%.

The regression coefficients observed for *N. hedleyi* acclimated in 20% S and experimented in various salinities varied from 05840 (in 25% S) to 0.6813 (in 30% S). Comparison of the 'b' values shows that in all the salinities the values are not statistically different.

The oxygen uptake rate of *N. hedleyi* acclimated in 5% S is found to be minimum in the acclimation salinity and increasing with increase or decrease in salinity, except in 25% S. In the case of animals acclimated in 20% S the oxygen uptake rate is minimum in the acclimation salinity and it increases in sub-and supranormal salinities. The above findings fully agree with the observations of other workers that in euryhaline animals the rate of respiration increases in sub- and supra-normal salinities. The study also reveals that the increased rate in sub-supranormal, salinities falls to the original level due to acclimation.

The fall in oxygen tension does not affect the oxygen uptake rate - body weight relationship of 5% S acclimated *N. hedleyi* in different test media, except in 15% S and 20% S where statistically different relationship has been observed at 20 mm HgPO$_2$.

The decline in the oxygen tension doesnot influence the oxygen uptake rate - body weight relationship of 20% S acclimated *N. hedleyi* in different experimental media, except in 3% S and 5% S where the 'b' values in lower partial pressures of oxygen show statistically significant difference.

In *T. furcifera* acclimated in 30% S, the regression coefficients remained statistically the same under declining oxygen tension upto 20 mm Hg PO$_2$.

Intra-and interspecific comparisons of the 'b' values of *N. hedleyi* acclimated in 5% S and 20% S and *T. furcifera* acclimated in 30% S under various oxygen tension show that the regression coefficients are not statistically different.

The variation in oxygen uptake rate in different salinities under various partial pressures of oxygen of *N. hedleyi* acclimated in 5% and 20% salinities shows that at higher oxygen tensions, the oxygen uptake rate is minimum in the acclimation salinity and it increases with increase or decrease in salinity, in general. But as the $PO_2$ declines this pattern is highly altered.

For *N. hedleyi* in the acclimation media of 5% S and 20% S and for *T. furcifera* in 30% S, the rate of oxygen uptake under falling oxygen tension is found to be constant over a wide range of oxygen tension. The critical level is found to be between 40-55 mm Hg $PO_2$ below which the rate declines. In the case of *N. hedleyi* in which metabolic studies have been conducted in different media, it is observed that the critical tension increases with decrease or increase in salinity and in extreme salinities the rate of oxygen uptake becomes dependent on the ambient oxygen tension. Thus in the case of *N. hedleyi* acclimated in 5% S the critical tension (Pc) is between 40-60 mm Hg in 3% S, 75-105 mm Hg in 0.60% S, 40-60 mm Hg in 10% S and 60-85 mm Hg in 15% S. In 20% S and 25% S the animals behaved like conformers. In the case of animals acclimated in 20% S Pc is between 60-80 mm Hg in 25% S, 80-105 mm Hg in 30% S, 100-120 mm Hg in 33.65% S, 60-75 mm Hg in 15% S and 80-100 mm Hg in 10% S. In 5% and 3% salinities the oxygen uptake rate falls as the $PO_2$ declines.

Thus *N. hedleyi* and *T. furcifera* are 'regulators' and they have an independent zone, a dependent zone and a critical zone in between. The capacity of these shipworms to regulate their oxygen uptake rate upto a very low $pO_2$ is of considerable significance for survival in oxygen deficient conditions.

## M.S.19. GEORGE, K.C. – Studies on the distribution and abundance of Fish Eggs and Larvae off the south-west coast of India with special reference to scombroids–1980– Dr. C.V. Kurian.

The major objective of this study was to assess the distribution and abundance of fish eggs and larvae along the SW coast of India and to delineate the spawning grounds and seasons of important commercial fishes, with particular reference to scombroids. The ichthyplankton collected by the UNDP/FAO, Pelagic Fishery Project, Cochin, from 1409 stations, mostly located on the shelf waters of the area from Ratnagiri to Tuticorin from Septermber 1971 to December 1975 formed the basis of the study.

High indices of fish egg abundance were noticed during the SW monsoon with consistently high concentrations in the central and southern sectors of the SW coast indicating the highest spawning activity of several commercial species, especially the pelagic ones during the SW monsoon season. *Auxis* larvae, the most abundant of all scombroid larvae were met with in all the months, but more from March to August, with the peak abundance in July. The larvae of *Rastrelliger kanagurta*, second in order of abundance among the scombroids were found throughout the year, with abundance among the scombroids were found throughout the year, with abundance in March to August and in November and the peak in July. The larvae of *Katsuwonus pelamis* occurred in significant numbers during February to April and in June. *Euthynnus affinis* larvae occurred more frequently in May and June. Larvae of *Thunnus* spp. occurred in small numbers from February to June and were caught mostly over the deeper shelf, beyond the 100 m depth zone.

Clupeoid larvae were distributed more densely in the areas south of Kasaragod

(12° 30'N) and showed considerably high abundance during the SW monsoon period. Larvae of *Stolephorus* spp. were the most numerous of the clupeoids and occurred throughout the year, with abundance in March to July and November. Sporadic large collections of eggs of *Sardinella longiceps* (sometimes more than 5000 $Nos./m^2$) were made in July and August between 9° 30'N - 12° 30' N, within 25 m depth zone. Larvae of *Sardinella* spp. dominated by *S. longiceps* occurred throughout the year, but predominantly during March to September period, with the peak abundance in July and restricted to the shelf area. Carangid larvae occurred throughout the year, with a predominance of *Decapterus* spp., more abundantly during May - June and October. The larvae of flat-fishes, mainly Bothidae and Cyno-glossidae occurred significantly from March to November with the maximum numbers in March - July period. Myctophid larvae were the most abundant of all larvae collected with the major concentration in a belt of 30 - 40 miles width, outside the shelf. The larvae occurred in all the months, but significantly from February to August with the peak abundance in July. Gonostomatid larvae, mostly *Vinciguerria* spp. occurred in a diffuse manner all over the surveyed area, with gradual increase towards oceanic waters upto about 100 miles outward from the shore. Larvae of *Bregmaceros* sp. occurred throughout the year, mainly during February-August period over the mid-shelf. Larvae of lizard-fishes mainly *Saurida* spp. and *Saurida* spp. occurred throughout the year, more abundantly during February - March Larvae of lizard-fishes mainly *Saurida* spp. and *Saurida* spp. occurred throughout the year, more abundantly during February - March and November period.

## M.S.20. ANTONY, A.–Studies on the Foraminifera of the south west coast of India–1980–Dr. C.V. Kurian.

Foraminifera constitute an important group of shell bearing protozoa. They are generally marine and widely distributed in the seas. The present investigation confines to a a study of the foraminifera in the estuarine environment viz Vembanadu estuary and the interstitial area of the sandy beaches of the south west coast of India with a view to correlate the distribution and intensity of the various species with hydrographic conditions and substrate characteristics.

Fortnightly collections of sediment samples were made for a period of 2 years (July 1973 to June 1975) from 15 stations along the length of about 65 km from Cochin barmouth in the north to Alleppey in the south. Environmental parameters such as water temperature salinity, dissolved oxygen, $p^H$ and nutrient contents were studied during the period of investigation. Live foraminifera in a unit area of $(10\ cm)^2$ surface sediment sample have been estimated.

Thirtytwo species of living foraminifera - 21 caleareous and 11 chitinous and siliceous forms were observed in the Vembanad estuary. The general distribution of the species shows that the lower reaches of the esyuary is characterised by caleareous species which are absent in the upper reaches. The species *Ammonia beccarii* is the most dominant caleareous form and constitute about 50% of the total foraminiferal population in the lower half of the estuary. The various species are classified into different groups based on the ecological conditions. Salinity is found to be the most important factor that controls the occurrence and distribution of foraminifera in the estuary. Seasonal occurrence of foraminifera shows maximum population during the pre-monsoon period and the minimum during monsoon period. The numerical density of living specimens per (10 cm)$^2$ surface sediment varies from 8 to 80 in the pre-monsoon period, 5 to 42 in the post-monsoon period and 0 to 11 in the monsoon period. The nature of the substratum has great influence on the distribution of benthic foraminifera. All the above aspects are discussd in detail in the first part of the thesis.

Investigation of the interstitial foraminifera from the intertidal area of the sandy beaches has been conducted. Samples were collected from 8 locations along the south west coast of India extending from Cannanore in the north to Cape Comorin in the south. Seventeen species of foraminifera are noticed in the area. The live specimens in 25 ml sample analysed vary from 5 to 48. The distribution of species at three tidal zones in relation to ecological parameters have been studied. Of the three zones, the low water level supports the maximum number of foraminifera in all the months. The correlation between sand grain size and foraminiferal population; seasonal variation in the live and dead shell ratios are also discussed.

## M.S.21. BALACHANDRAN, T.–Studies on Meroplankton–1981–Dr. C.V. Kurian.

Plankton community, drawn from a very wide variety of animal phyla, formed the basic food supply of marine life and indicators of water mass. The term meroplankton generally referred to that portion of the zooplankton which is transient in nature, remaining rest of their lives in the nektonic or benthic environment. This group was selected for intensive studies, considering the role of meroplankton in the economy of the sea and the scarcity of literature on them from the Indian Ocean. The present study besides providing information regarding the fixation and preservation techniques and biochemical aspects of tropical meroplankton, also consolidates information regarding their zoogeography in the Indian Ocean region, with a view to amplifying the limited information available from this area.

The distribution studies are based on the collections made during the International Indian Ocean Expedition (1960-65), whereas the material for preservation and biochemical studies was collected from the coastal waters during 1968-1978.

*Salient features:-* 2% of formaldehyde buffered with 2% borax, added to the plankton in the ratio of 9:1 was found the best fixative. On fixation the plankton underwent shrinkage due to loss of 15 to 87% water. Addition of antioxidants prevented colour fading. Narcotization by different specific reagents prior to fixation reduced distortions due to violent reaction and improved morphological conditions. One percent formaldehyde solution in sea water buffered with borax or neutralised with calcium carbonate perfectly preserved majority of meroplankton. Equally good was one percent propylene phenoxetol buffered with borax.

Biochemical compostion of valoous taxa showed variations according to their age class, size groups metamorphosing stage, feeding mechanism, type of organism fed and time of collection.

General distribution studies of 4 meroplankton taxa - Anthozoan larvae, cirripedia larvae, sipunculoid larvae and gastropod larvae showed abundance in the coastal areas especially during the SW monsoon period. Based on the larval distribution different zoo-geographical areas in the Indian Ocean are differentiated. Studies on annual variation along the meridian 78° E longitude revealed annual distinct fluctuation in abundance of all groups. The seasonal amplitude of meroplankton taxa in a pelagic ecosystem between 9° S and 32° S along the 110° E longitude was found low, but none the less significant. Diurnal variation showed higher value at night. Distribution studies in the western Indian Ocean in relation to the thermocline indicated that it is not a barrier for the distribution of fish larvae. The results showed that the light controlled vertical migration than the temperature.

## M.S.22. THOMAS P. THOMAS – Studies on the Enzyme Glucan Phosphorylase – 1982 – Dr. George Philip.

The thesis has two parts. Part I deals with studies on rabbit muscle glycogen phosphorylase and Part II deals with glycogen phosphorylase from the mantle muscle of the marine invertebrate *Sepia pharaonis*.

### Part I

Inhibition of the rabbit muscle phosphorylase *a* and *b* was examined using *m* and *p*-nitrophenyl phosphate, p-nitrophenyl ß-glucoside, *p*-nitrophenyl ß-arabinoside, ATP and glucose-6.P. Sigmoidal saturation curves were obtained for phosphorylase *b* in the presence of each of these inhibitors. Inhibition of phosphorylase *a* by the above compounds was of the mixed type. Location of the binding domain in the enzyme was analysed using isobologram. The results indicated that all these ligands bind either mutually exclusively or nearly so on the same location in the enzyme near the monomer/monomer interface where the binding sites of glucose-1-P and AMP are also located. AMP afforded some protection of activity. Nitrophenols were the most effective inhibitors. Based on the degree of inhibition by these inhibitors, a mechanism of different modes of binding by ligands on the same region in the enzyme was presented to explain the special properties of phosphorylase.

The bifunctional reagent 1,5-difluoro-2, 4-dinitro-benzene was used for further studies to locate the aromatic binding site, and to prepare an aromatic derivative of the enzyme. The reaction with phosphorylase *b* was found to be very specific at low concentration of the reagent and resulted in inactivation of the enzyme at a rate much faster than by 1-fluoro-2,4-dinitrobenzene.

Glucose-1-Phosphate, glucose-6-P, AMP and ATP afforded some protection against inactivation by 1,5-difluoro-2,4-dinitrobenzene.

Glucose-1-phosphate, glucose-6-P, AMP and ATP afforded some protection against inactivation by 1,5-difluoro-2,4-dinitrobenzene. The above ligands and aromatic compounds were shown to bind on the enzyme in the same region which is located near the monomer/monomer interface.

An apparently homogeneous dinitrophenylene derivative of phosphorylase *b* with only one group incorporated per dimeric enzyme and having 50% of the catalytic activity was prepared. In the derivative, subunits were not cross-linked. It was devoid of the homotropic cooperativity for the substrate or activator site even in the presence of allosteric inhibitors. Spectroscopic analysis of the derivative showed that one lysyl and one tyrosyl residues were modified, which resulted in the desensitization of the enzyme. The derivative was structually different from the native enzyme as evidenced from its comparatively higher instability to urea, temperature and the lower reconstitution rate of apodinitrophenylene enzyme. The derivative could be converted to the *a* form like the native enzyme.

Glucose behaved quite differently from other ligands in its effect on inactivation by the reagent and on the kinetics of the modified enzyme derivative. The results showed that glucose, unlike the other ligands did not bind on the aromatic binding site. Also, the binding of glucose was found to cause allosteric transitions.

Rabbit muscle glycogen phosphorylase at higher concentrations was found to effect a slow hydrolysis of *p*-nitrophenyl phosphate and similar nitrophenyl compounds. This effect was established as due to non-specific effect of some amino acid resiudues on the enzyme.

### Part II

α-glucan phosphorylase from specialised tissues of marine and estuarine invertebrates have not been subjected to detailed studies. Glycogen phosphorylase *a* was purified to homogeneity from the mantle muscle of the Cephalopod *Sepia pharaonis*. The mantle tissue is very much similar to the flight muscle of insects. The molecular weight of the phosphorylase purified was about 200,000. Estimation of the pyridoxal-5'-phosphate and the molecular weight suggested that the enzyme was a dimer. The kinetic mechanism was consistent with rapid equilibrium randum *bi bi*, similar to the enzyme from other sources. The kinetic constants in the direction of glycogen synthesis were evaluated.

The *S. pharaonis* phosphorylase was found to be specifically activated by L – cysteine considerably (about 3-fold) unlike phosphorylases from other sources reported so far. Cysteine shifted the 335 nm band of the *Sepia* enzyme to 300 nm. These two effects of cysteine were found to be independent. The effect of cysteine was explained by a specific structural change which conferred an increased hydrophobic character near the PLP site. Such a change should aid in maintaining a fully protonated form of PLP.

The *Sepia* phosphorylase *a* was not inhibited by glucose-6-P, glucose or ATP in the presence of 1 mm AMP, like its rabbit counterpart. However, unlike in rabbit phosphorylase *a*, in the absence of the nucleotide, the *Sepia* enzyme was only slightly inhibited by glucose and not at all by ATP. As with rabbit phosphorylase *a*, aromatic compounds showed mixed inhibition with the *Sepia* enzyme. The enzyme was found to be more sensitive to cold inactivation. Based on the results, a mechanism for 'cold inactivation' was suggested. It may be noted that cold inactivation first observed for the rabbit enzyme has not yet been satisfactorily explained.

The control mechanism of the glycogen phosphorylase from *Sepia* was found to be different from other animal muscle phosphorylases. The *Sepia* enzyme exhibited negative homotroic cooperativity between AMP site. Fresh *Sepia* muscle contained active phosphorylase phosphatase and kinase which became inactivated on freezing of the muscle. Rabbit muscle phosphorylase phosphatase and kinase did not interconvert the *Sepia* phosphorylase suggesting structural differences. The animal was found to maintain a very high concentration of AMP (about 3.5 mM) in its mantle tissue. The high energy demand of the mantle was met by this high concentration of AMP such that enzyme would be fully active whether it was present in the *a* or *b* form. Therefore interconversion between AMP-dependent and AMP-independent forms of phosphorylase did not appear to be a s major controlling factor of glycogen degradation, unlike in other cases studied so far.

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## M.S.23. HRIDAYANATHAN, C.–Studies on the Macrobenthos of the Mudbanks of Southwest Coast of India–1982–
## Dr. C.V. Kurian

The study was undertaken with the objectives to assess the distribution and density of population of benthic animals with special reference to macrofauna from the south west coast of India from Lalippuram in the north to Alleppey in the south, be evaluate significant difference, if any, in the number and distribution of animals in the mud bank regions and other intermittant stations, to examine the influence of bottom stability on the distribution of fauna, to observe the effect of the environmental parameters on the distribution pattern of macrofauna, and to evaluate the nature and depth-wise distribution of the benthic fishery. The region selected for the investigation is one of the most important fishing grounds in India for bottom fishing especially for prawns, covering a distance of about 60 kms in length.

A total number of thirty stations in five transects at right angles to the coast, each consisting of six stations were surveyed. The six stations in a transect were at depths of 5m, 10m, 20m, 30m, 35m and 45m respectively. Bottom deposits and water samples from surface and bottom have also been collected from each station to study the environmental parameters. The investigation was carried out during the years 1972 and 1973 and the collection of the samples corresponded to pre-monsoon, monsoon and post-monsoon periods. The profiles of the present study consisted of three mud banks and an intermediate region so as to make comparisons in the abundance of macrofauna in the two types of grounds. The analyses of the bottom fauna indicated that most of the organisms belonged to three groups: Annelida, Crustacea and Mollusca. A few species of Coclenterata, Nemertini, Echinodermata and Echiuroidea were also present.

The quantitative distribution of the macrofauna showed that the maximum number of organisms was near the 35m contour line in the first three profiles whereas in the fourth and fifth profiles it was at 20m and 30m depth respectively. The density of the fauna was comparatively poor in shallow water stations at depths 5-10m. There is no significant variation in the faunal assemblage and intensity in the different profiles. The maximum number of animals however was recorded from a station in the third profile which is located outside the influence of the mudbank. As a whole the values of biomass were higher in deeper stations except in the third profile, where the shallowest station 13 showed high value. The percentage composition study of the different group indicated that the polychaetes formed an average value of 75.5%; the crustaceans varied from a minimum of 0.8% to maximum of 46.15%, while the value of molluscan fauna varied from a minimum of 1.3% to a maximum of 31.4%. There was a general decline in the numerical abundance and biomass of the bottom fauna in all the stations during the monsoon period. There has been very little yearly change in the composition of the fauna during the two years' study. The absence of any significant difference in the number and weight of animals in the stations of profiles A,B,D,E (mud banks included) and profile C (Outside mud banks) showed that higher content of organic materials available in the sediment was not the only decisive factor which detemined the standing crop. A stable substratum in the mud bank regions is not possible due to the fluid nature of the mud, moblity of the mudbanks and possibly due to heavy fishing activity particularly bottom trawling. The absence of any predominant species and the occurrence of other animals in smaller numbers rule out the possibility of any clear indication of any particular community existence in the area.

In the present study, the Alleppey mud bank was selected for field observations of the fish landings. The species-wise composition and the quantity landed by the country crafts were observed for three consecutive days in the second weeks of June, July and August in the years 1972 and 1973 which are the active periods of mud bank formation. Based on the abundance and catch per hour return of the different species, the fishing ground trawled was divided into three zones viz. (1) 5-20 m zone (ii) 30-35 m zone (iii) 45 m zone. The second depth zone was found to be more productive contributing 43% of the total catch which was lying beyond the influence of the mudbank formation. The catch composition of the fishery from near shore depths in other fishing grounds have also been examined from other fishing vessels of the institute which does not show any significant difference from the profiles selected for the present study. The analysis of the trawl fishery data emphasises the observation that the formation of the mud bank and the fishery in these regions are not interdependent.

## M.S.24. LAKSHMANAN, P.T.–Investigations on the Chemical Constituents and Tracemetal Interactions in some Bivalve Molluscs of the Cochin Backwaters–1982–

## Dr. P.N.K. Nambissan

Studies on the seasonal variations of biochemical constituents and some of the tracemetals like copper, zinc, iron & lead, the lethal and sublethal effects of toxic metal ions, viz., $Hg^{2+}$, $Cu^{2+}$, $Zn^{2+}$ & $Pb^{2+}$ and the accumulation and depuration kinetics of these metals were carried out in three commercially important molluscs, viz., *Villorita cyprinoides* var. *cochinensis, Meretrix casta* (Chemnitz) and *Perna viridis* (Linnaeus) of the Cochin backwaters.

The biochemical constituents showed a distinct seasonal change in all the three molluscs. The body water content was the highest during monsoon months and it showed significiant negative correlation with habitat water salinity. Protein and carbohydrate levels showed an inverse relationship in these species. Increase in lipid level was accompanied by an increase in total phosphorus. Highest calorific values were obtained during December to February for *V. cyprinoides*, December to April for *M. casta* and June-July in the case of *P. viridis*, suggesting the best harvesting period.

The tracemetal content in the molluscs also varied with season . Highest metal concentrations in general, were found when the habitat water salinity and pH were low i.e. during the monsoon periods and low values, during summer. Significant negative correlations ($P \leq 0.001$) existed between tracemetal content and salinity. Nearly all the four metals were positively correlated in the two clams. In *P. viridis*, only a few combinations (Cu/Zn, Cu/Pb and Zn/Pb) were significantly correlated. Iron was the most abundant tracemetal in all the three species. The levels of these metals were below the permitted limit in seafoods.

Among the different metals tested for toxicity, copper was found to be the most toxic metal ion to all the species. The order of toxicity was $Cu^{2+} > Hg^{2+} > Zn^{2+} >> Pb^{2+}$. Upto 10 ppm, lead did not cause lethality to the molluscs in 10 days period. The mussel, *P. viridis* was found to be more susceptible to heavy metal ions than the two clams. In *P. viridis*, the 96 h-$LC_{50}$ values were 0.174 ppm Cu, 0.34 ppm Hg and 3.0 ppm Zn in *V. cyprinodies* the corresponding values were 1.214 ppm Cu, 1.57 ppm Hg and a 10 day $LC_{50}$ value of 5.47 ppm Zn. The 96 h-$LC_{50}$ values of these metals in *M. casta* were 2.188 ppm Cu, 3.25 ppm Hg and 6.67 ppm Zn. The difference in the toxicities of these metals is explained on the basis of their electronegativity data, the ionic radii and the pKs values of the metal sulphides.

Under sublethal concentrations of $Cu^{2+}$ and $Hg^{2+}$, the tissue lactic acid increased considerably in the molluscs with a concomitant fall in the glycogen level. The lactic acid content increased with increasing concentrations of metal ions and time of exposure. The severe anaerobic stress caused by metal intoxication, resulted in the breakdown of tissue glycogen.

Bioaccumulation of the tracemetals viz., Hg, Cu, Zn and Pb from water occured at all concentrations studied. The metal content in the animal soft parts were found to be dependent on the concentrations of metals in the medium and length of exposure. Except for Zn, highest concentration factors (CF) were attained by *P. viridis* for these metals (Pb = 2469, Cu = 2450, Hg = 2179 and Zn = 219) during 6 days' exposure (dry wt. basis). *V. cyprinodies* showed higher CFs for Zn, Hg and Pb than *M. casta*. The highest CF for Zn was obtained by *V. cyprinodies* (534). The CFs decreased with increasing concentrations of the metals in the medium (exception Pb) showing greater uptake efficiency of lower concentrations. The study revealed gills as the major storage organ of metals in molluscs. The efficiency of metal uptake was ranked as *P. viridis* > *V. cyprinoides M. casta.*

The depuration of metals in a metal free media was generally, a slow process. Copper was found to be depurated faster by all the species. Total purification of metals could not be achieved in any case during a cleaning period of 20-24 days. These studies establish the usefulness of molluscs as indicators of metallic pollution; the present investigation is the first ever risk in 'mussel watch' in India.

## M.S.25. PETER, K.J.–Studies on some fish larvae of the Arabian Sea and Bay of Bengal–1982–Dr. C.V. Kurian

The major objective of this study was to asses the composition, distribution and abundance of fish larvae of the Arabian Sea and Bay of Bengal during the period from 1960 to 1965 based on the collections of the International Indian Ocean Expedition. The quantitative data obtained have been used to determine the relative abandance and distribution of larvae both in space and time with a view to providing information for the stock assessment and management of fishery resources of the region.

The important oceanographic parameters such as topography, current system, water masses, upwelling, hydrological parameters and zooplankton biomass of the area studied during the expedition were reviewed with the aim of finding out the possible correlation with the abundance and distribution of fish larvae.

Fish larvae numbering 53486, separated from 935 standard zooplankton samples were identified and grouped into 54 families. The larval characters, area, period of occurrence and percentage contribution of fish larvae belonging to 45 groups were dealt with in detail.

Larvae of scopeliform fishes outnumbered all the rest of the groups in percentage of abundance contributing to 26.7% of the total lavrae collected. Of these Myctophidae ranked first with wide-spread oceanic distribution. Gonostomidae ranked second in abundance contributing to 12% of the total larvae collected. Clupeoidesd comprising of coastal species such as sardines and anchovies which were also recorded in the offshore waters contributed to only 3.8% of the larvae collected. Of these, the major share was that of engraulids. Bregmacerotidae which was third in the order of abundance contributed to 3.7%. Among percoids, carangids had the highest contribution of 1.2%. Scombroids like Thunnidae, scombridge, scomberomoridae and Histiophoridae contributed to 0.95% of the total. The general distribution of fish larvae showed higher abundance in the coastal and offshore waters. Based on their distribution, nine different zoogeographical areas reflecting the hydrological regimes in the Arabian Sea and Bay of Bengal were differentiated.

Numerical abundance of fish larvae ranged from 0 - 1600 per haul and comparatively high values were noticed towards the western sea Arabian Sea, and western Bay of Bengal. The record of higher numerical abundance of larvae in the Bay of Bengal than in Arabian may probably be an indication of the presence of a hitherto unexploited fishery. Distribution studies of fish larval population based on four seasons indicated the concentration of larvae as large patches with maximum during May-August and minimum in September-October period showing the effect of monsoon. Month wise distribution studies in the Arabian Sea revealed great fluctuations in the distribution pattern showing maximum abundance in July and considerable fall in May-December months, whereas in Bay of Bengal the maximum yield of larvae was in February and minimum in December. Analysis of day and night catches of fish larvae indicated nocturnal abundance more than double of that during day.

The distribution and abundance of larvae in relation to environmental parameters such as salinity and temperature showed that majority of the families occurred both in the Arabian Sea and Bay of Bengal irrespective of the differences in the range of salinity and temperature. Areas of high abundance of larvae and their continuous occurrence over extensive periods observed in several cases could be looked upon as indication of spawning grounds and breeding season. Distribution of engraulids indicated the presence of an exploitable resource of that group in the offshore waters. The resources of sconbroids, particularly tunas and certain other perciform fishes also are appreciable in the offshore and oceanic waters. Another probable exploitable resource of the oceanic waters is the Myctophidae.

The above findings provide valuable basic information for the exploitation of the fishery resources of the Arabian Sea and Bay of Bengal as they help in the detection of spawning ground and breeding season and also in the estimation and assessment of the commercially important species. A study of this kind and magnitude for this area is unique and made for the first time.

### M.S.26. GOPALAKRISHNAN, T.C. – Studies on the Planktonic Copepods - Calanoida: Scolecithricidae-of the Indian Ocean 1982 – Dr. C.V. Kurian

Plankton forms the basic food supply for marine life, especially to fishes. The

areas of abundance of zooplankton were found to support the areas of world's commercial fisheries.

Copepods, though small in size, are the most abundant of all crustaceans, forming the bulk of the animal substance of the sea, accounting for about 70–90% of the zooplankton. Being the major primary consumer and the efficient link in the marine food web, its study is one of atmost importance. Among the copepods calanoids rank first in abundance and among calanoids scolecithricid copepods are found in all the oceans with their abundance in the tropics.

Our knowledge on the taxonomy and distribution of the scolecithricid calanoids from the Indian Ocean is mainly based on some of the earlier expeditions in this region. No attempt has hitherto been made for such a comprehensive study involving methodically collected samples covering the entire Indian Ocean. The main purpose of this study was to outline the main distributional features of the species of the calanoid copepod family Scolecithricidae in the Indian Ocean and to distinguish and describe their niches.

The study was carried out using the zooplankton samples collected from the euphotic zone of the Indian Ocean, during the International Indian Ocean Expedition, 1960–65.

Twenty seven species of Scolecithricidae, belonging to 7 genera were identified. Their taxonomic features were briefly described with the help of suitable illustrations. One species viz *Macandrewella cochinensis* was described as a new species. *Scolecithricella tropica* and *Scottocalanus australis* were new records from the Indian Ocean.

*Scolecithrix danae*, *Scolecithricella bradyi*, *Scaphocalanus echinatus*, *Scolecithricella ctenopus*, *S. tenuiserrata*, *S. dentata*, *S. abyssalis* and *Scaphocalanus curtus* had high frequency of occurrence being present in 82.3, 63.6, 34.3, 31.7, 49.1, 34.0, 43.4 and 35.1% of the total stations and contributed to 59.7, 6.5, 6.2, 5.1, 4.4, 3.7, 3.6 and 3.4% of the total Scolecithricidae collected.

*Scolecithrix nicobarica*, *Lophothrix angusta*, *Scolecithricella marginata*, *Amallothrix indica*, *Scolecithricella vitata*, *Scottocalanus dauglishi*, *S. securifrons* and *Scolecithricella ovata* had low numerical abundance of 1.6, 1.1, 1.0, 0.7, 0.5, 0.5, 0.4 and 0.4% of the total Scolecithricidae, but with a medium range of occurrence of 19.5, 27.5, 13.8, 8.6, 17.1, 7.3, 11.2 and 14.3% respectively in total stations.

The remaining 11 species viz. *Scaphocalanus longifurca*, *S. affinis*, *Scolecithricella tropica*, *Amallothrix arcuata*, *Scottocalanus*, *persicans*, *S. farrani*, *S. helenae*, *Lophothrix frontalis Macandrewella cochinensis*, *Scottocalanus australis* and *S. thomasi* were rare species contributing to 0.3, 0.1, 0.1, 0.02, 0.003, 0.2, 0.1, 0.1, 0.2, 0.02 and 0.03% respectively of total Scolecithricidae and having very low frequency of occurrence of 2.9, 3.9, 3.1, 0.3, 0.3, 2.6, 2.1, 2.6, 1.0, 1.8 and 1.0% respectively in total stations.

*S. vitata* and *M.cochinensis* were nonmigrant, near surface species and *S. curtus* was a nonmigrant mid water species. Others were extensive migrants undertaking nocturnal migrations in the neritic and oceanic waters.

The most abundant and widely distributed, *S. danae* contributed to a higher production during southwest monsoon period whereas 19 other species showed intensive production during northeast monsoon period.

Of the 27 species 18 were common to Indian, Atlantic and Pacific Oceans, 6 were confined to Indo-Pacific waters and 3 were endemic to the Indian Ocean.

Two species were neritic as well as oceanic in occurrence and abundance, 17 were oceanic and 8 were neritic.

The following 10 patterns of distribution were noticed.

1. 25°N–40°S: *S. danae, S. curtus* and *S. bradyi* - tropical and subtropical.
2. 25°N–30°S: *S. echinatus* and *S. tenuiserrata.*
3. 25°N–20°S: *S. abyssalis, S. ctenopus* and *S. nicobarica.* - mostly tropical.
4. 25°N–10°S: *S. marginata* and *S. longifurca.*
5. North of equator
(Arabian Sea and: *A. indica, S. dauglishi* and *M. cochinensis.* Bay of Bengal).
6. 10°N–40°S: *S. dentata, S. tropica* and *L. angusta..*
7. 10°N–30°S: *S. vitata.*
8. 10°N–20°S: *S. securifrons, S. ovata* and *S. helenae.*
9. 10°N–10°S: *S. affinis, S. farrani* and *L. frontalis* - purely tropical
10. South of equator upto 20°S: *S. australis* and *S. thomasi.*

Species diversity increased from neritic to oceanic waters. Around 3 species per haul were present in neritic waters and upto 15 in the oceanic waters.

Studies on the co-existence of species showed that *S. danae* and *S. abyssalis* were significantly correlated with 75% of the rest. *S. danae, S. bradyi, S. abyssalis, S. ctenopus, S. echinatus, L. angusta, S. nicobarica, S. tropica* and *S. thomasi* were significantly correlated with 60% of the rest. The correlation coefficient matrix showed that more than 75% species had different environmental requirements. Salinity was the most important factor followed by temperature and oxygen in the Arabian Sea, oxygen followed by temperature and salinity for Bay of Bengal, oxygen followed by salinity and temperature for southwest Indian Ocean and none was significant for the southeast Indian Ocean. For the Indian Ocean as a whole the order of significance was salinity followed by oxygen and temperature. A multiple regression model significant at 1% level indicated that the fitted regression was capable of explaining only 11% of the variables in the prediction of the abundance of Scolecithricidae. Calculation of Fishers diversity index ∝and its variation showed that the type of environments in the different areas of the Indian Ocean were more or less of the same kind.

## M.S.27. GOPINATHAN, C.P. - Studies on the Phytoplankton in the Estuarine and Marine Environments - 1983 - Dr. P.V. Ramachandran Nair.

This is a study on phytoplankton and productivity in various ecosystems such as estuary, inshore and oceanic environments and some special ecosystems such as prawn culture fields, mangroves, mud banks and Andaman Sea. The thesis also embodies the results of culture studies based on six different media carried out for mass production in hatchery operations. The toxicity of phytoplankton towards six hydrocarbons has been studied. The general level of productivity of the Exclusive Economic Zone of India comprising an area of 2 million sq. km. has been computed and the potential yield of harvestable resources from this area has been worked out based on phytoplankton production. The annual production for the entire EEZ has been computed at 283 million tonnes of carbon equivalent to 12000 million tonnes in wet weight. The estimate of the potential yield of fish accordingly is about 5 million tonnes.

A taxonomic account of 109 species of littoral diatoms and 67 species of dinoflaggellates along with their occurrence and distribution has been included. Of these 49 species of diatoms and 8 species of dinoflaggellates are found to be new distributional records for the Indian Seas.

## M.S.28. PADMINI, R.- Studies on Energy Exchange Between Sea and Atmosphere from the Indian Ocean - 1983 - Dr. A.V.S. Murthy.

An attempt is made to assess the large space-scale and time history of the energy flux fields, over the Indian Ocean north of 40°S latitude and its adjacent seas. Energy fluxes through the surface have been calculated using bulk aerodynamic equations with exchange coefficients which vary with windspeed and radiation equations based on Budyko.

The inter-annual variations of sea surface temperature are studied and the annual variations of the sea surface temperature, air temperature and sea level pressure are studied using harmonic analysis.

Unlike North Atlantic and Pacific, the North Indian Ocean shows highest values of evaporation during summer.

Northern Indian Ocean shows unique behaviour in its distribution of marine meteorological parameters and subsequent interaction with the atmosphere.

Large amounts of radiation energy are available in the western Arabian Sea for the genesis of the Indian monsoon and its movement. The same region shows the maximum advection of cold water, due to intense upwelling during summer monsoon months.

During transitions, Bay of Bengal on account of warmer waters exhibit more evaporation, since the wind speed values are much low, where as during summer monsoon season, when the zonal anomalies are at the maximum, with very low values of cold upwelled waters in the western Arabian Sea, on account of high speed winds of monsoonal current, western Arabian Sea exhibits more evaporation.

The quantitative assessment of zonal difference in the hast budget shows that the host budget is basic to the climatic assymmetry between western and eastern portions of the low-latitude oceans.

The time-series of heat balance and its components show that the annual course of the heat balance is disrupted during individual years and months chiefly as a result of a sharp increase or decrease of evaporation. The intensity of heat emissions and its periodic variations throughout the North Indian Ocean and its relation to the gigantic event of monsoon is clearly seen.

The influence of general cicumlation over the sea surface temperature or vice versa, where the cause and effect is difficult to be differentiated is obvious from the results.

A significant positive correlation, between simultaneous monthly water temperature during south-west monsoon from the western Arabian Sea and the intensity of monsoon, is observed.

The harmonic analysis of sea surface temperature, air temperature and sea level pressure indicates latitude dependence, with a tendency to show higher oscillations over the western side of Arabian Sea and Bay of Bengal.

The far-reaching sea surface temperature anomalies in the western Arabian Sea is quite astounding. It is clear that cold water anomalies along with the proximity of vast landmass creates the unique situation during northern summer.

The differentiation of cause and effect between SST and monsoon activity is not clear. Here most of the time the development of intense upwelling and cold water advection is arbitrarily chosen as starting point, which leads to a chain of events. However, it can be said that the monitoring of the largescale air-sea interactions as a consequence of sea surface temperature anomalies will have great impact on future attempts in climatic forecasting.

## M.S.29. THANKAPPAN PILLAI, C. - Studies on finfish and Shell fish Diseases - 1983 - Dr. E.G. Silas.

In the present investigation by the candidate, Fifteen types of diseases due to virus, bacteria and fungi such as black spot disease, enteritis, eye disease, fin rot, gill rot, hemorrhagic septicemis, muscle necrosis, shell disease, skin lesion, skin spottiness, streptococcosis, tail rot, proliferative epithelial tumour, deep mycosis and dermatomycosis are documented in twenty one species of finfishes and shellfishes and the causative factors studied. Among these, the diseases of bacterial origin predominated, occurring in nineteen species of finfishes and shellfishes. The gungal diseases, dermatomycosis occurred in the finfish, *Anquilla bicolor bicolor* and deep mycosis in the larvae of *Penaeus indicus*. Proliferative epithelial tumour due to viral infection was detected in a species of finfish, *Arius jella*.

In total 115 bacterial strains were isolated among which Gram negative asporogenous rods predominated.

Only seven bacterial strains, *viz*., *Vibrio anquillarum*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Escherichia coli*,*Streptococcus pyogenes* and *Proteus vulgaris* and one fungal strain, *Penicillium* sp. could be categorised as definitely pathogenic.

The obligate pathogens were further studied for their sensitivity to various therapeutic agents which are used for the treatment of finfish and shellfish diseases.

The effect of the antiseptics and the antibiotics varied from pathogen to pathogen. However, the antiseptics, acriflavine and silver nitrate were found quite effective. The antibiotics gentamycin, chloromycetin, kanamycin and terramycin were powerful enough to cure the microbial diseases.

Studies on haematological parameters revealed the fact that in the case of diseased fishes there existed a sharp decline of value of haemoglobin resulting in anaemia as compared to the normal healthy fish.

## M.S.30. MUKUNDAN,M.K.-Studies on Fish Lipases -1983 -Dr. K. Gopakumar

Oil sardine contains significant amounts of lipase distributed in its body organs, of which hepatopancreas has the maximum concentration viz. 126 units per gm wet weight of hepatopancreas.

A method to purify lipase from the hepatopancreas of oil sardine has been worked out. Pure sardine lipase was prepared at a yiels of 35% at a specific activity of 940 units. The method consists of four major steps, which are Steps 1. Defatting hepatopancreas. Step 2. Ammonium sulphate fractionation. Step 3.

DEAE sephadex ion exchange chromatography; Step 4. Sephadex G-100 column chromatography.

The sardine lipase protein upon chromatography on sephacryl S-200 gave only one peak. Further on polyacrylamide gel electrophoresis it gave only one band. Molecular weight estimation by gel filtration on sephadex G-100 and SDS acrylamide electrophoresis gave a value of 54500. Carbohydrate analysis of sardine lipase showed the presence of 6.1% carbohydrate. The carbohydrates present in sardine lipase were glucose, arabinose and xylose in 1:4.8:4.2 proportion. Amino acid analysis data revealed that sardine lipase protein do not contain any sulphur amio acids. Sardine lipase is not an SH. enzyme.

Sardine lipase had pH and temperature optima at pH 8 and 37 °C respectively. The enzyme was stable up to a temperature of 45°C. It was also stable in the pH range 5 to 9.5.

A variety of molecules and ions were inhibitors of sardine lipase.

Studeis with various substrates showed that sardine lipase hydrolyses a variety of substrates like various triglycerides, 1-mon-glycerides and diglycerides.

Lipolysis of the neutral triglycerides of sardine oil and coconut oil by sardine lipase showed that lauric acid was released preferentially at a higher rate than the next higher acids and decanoic acid ($C_{10:0}$). Further the acids with odd carbon number viz. $C_{15:0}$and $C_{17:0}$ were released at substanitially higher rates than the fatty acids $C_{14:0}$, $C_{16:0}$ etc with even number of carbon atoms.

Saridine lipase was found to have triacetin and $12 \times 10^{-6}$ for tributrin as substrates.

Sardine lipase is specific for 1 ester bond and the lipolysis observed with 2-monocaprylin is due to the hydrolysis of 1 monocaprylin formed as a result of acyl migration of the acyl group from 2-position to 1-position.

Sardine lipase was immobilised in polyacrylamide gel. The immoblised enzyme showed 65% to 70% of the activity of the native enzyme. It was observed that immobilised sardine lipase was more stable than the native enzyme that it can be stored at 0°C for 4 months without any loss in activity.

## M.S. 31. T.K. GOVINDAN-Studies on the freezing technology of commercially important species of prawns-1983-Dr. C.T. Samuel

The most important item of seafood exported from India is frozen prawns. The seafood industry in India produces over half a dozen varieties of frozen prawns to suit the requirements of the export market in different countries.

The study included a review of the seafood industry in India and the different items of frozen shrimp products in the export trade. A detailed narrative of the production technology of the important items of frozen shrimps is the most important part of the investigation. Extracts from the data available in the Central Institute of Fisheries Technology, Cochin regarding the Freezing Technology of shrimps were utilised to suggest recommendations for improvements in the freezing technology of shrimps.

## M.S. 32. MADHUSOODANA KURUP, B.–Studies on the systematics Biology of the fishes of the Vembanad Lake–1983–Dr. C.T. Samuel.

A detailed investigation on the Systematics, Distribution and Ecology of all fish species of the Vembanad lake was carried out during the period from October 1978 to September 1980 and biological studeis were conducted on selected species of commercially important fishes of the lake during the period from January to December, 1980.

150 species of fishes belonging to 100 genera and 56 families were identified from the Vembanad lake.

Among the physico-chemical parameters studied, the pattern of the variation of temperature was bimodal.

The occurrence, season and frequency of the 139 species of fishes recorded from the lake are presented.

An attempt was made to correlate the distribution and abundance of fishes with the fluctuating physico-chemical paramoters of lake. The result shows that salinity is the most significant controlling factor on the type of fish fauna of the lake and their distribution and abundance, both seasonally and geographically.

Mass mortality of fishes were frequently observed from Eloor-Varapuzha regions of the lake during February to May.

The biology of the two commercially important fish species of Vembanad lake viz. *Daysciaena albida* (Cuvier) and *forres filamentosus* Cuvier are investigated.

The analyses of the food feeding habits of *D. albida* of the lake reveal that prawns, teleosts, juvenile crabs, amphipods and isopods formed the major part of the diet.

The food of *G. filamentosus* was represented mainly by amphipods, isopods, polychaetes, juvenile crabs, filamentous algae and diatoms.

In *G. filamentosus*, the regression coefficients between males and females are insignificant at 5% level.

The breeding biology of *D. albida and G. filamentosus* of Vemband lake was studied.

The spawning season of *D. albide* was found to be during the months from July to November.

This is confirmed by the percentage occurrence of fully mature specimens and high ISI values.

Individuals *D. albide and G. filamensosus* spawn only once within a definite spawning period.

## M.S.33. BASIL MATHEW–Studies on upwelling and sinking in the seas around India–1983–DR–Dr. G.S. Sharma

Upwelling is the process by which subsurface waters of the sea are brought to the surface layers, while the reverse process is called sinking. Upwelling is a common feature in the coastal areas where the prevailing winds drive waters offshore. Upwelling also occurs in regions of diverging horizontal currents and in the equatorial regions. The cool nutrient rich upwelled waters promote higher

productivity and modify the local climate.

The thesis addresses the problem of coastal upwelling off the east and west coast of India. The inference on upwelling is made basically from the analysis of temprature data collected once in a month at typical locations off the coasts of India. Further supporting evidence is obtained from the analysis of density field, surface divergence surface wind stress and sea level variations on a monthly mean basis. The analysis and interpretaion of results is presented in five chapters followed by summary and conclusions.

The process upwelling generally starts off the southwest coast of India by March with the reversal of surface currents to southerly. The cool subsurface waters of the thermocline generally reaches the surface with the onset of the southwest monsoon. Near the coast the surface water cools to as low as 22 C by August. However, the intensity of upwelling is found to be less towards north with a time lag of about one month (off Goa compared to that off Cochin) in the occurence of coldest water at the surface. It is also found that the local northwesterly winds during summer monsoon plays a major role in producing this upwelling. The intensity of upwelling is less towards north where the wind system gradully changes to westerly and even southwesterly (off Bombay) during this period. The reverse process of sinking generally occur by end October/early November off Cochin. From the monthly displacement of isotherms it is estimated that the velocity of upwelling is of the order of $10^{-3}$ during summer monsoon.

Off the east coast of India upwelling starts in February and continues till July/August while sinking persists during the remaining preiod. The southwesterly local winds from February/March promotes upwelling especially off Waltair. The intensity of upwelling off the east coast of India is generally lower than off the southwest coast of India is probably in association with greater stratification due to massive river discharges. Further upwelling is found to be stronger off Waltair compared to off Madras. It appears that the orientation of the coast also favours stronger upwelling off Waltair.

Summary of the results and conclusions is presented in Chapter six including proposals for future investigations.

## M.S. 34. NARAYANA PILLAI, V.–Physical characteristics of the coastal waters off the south-west coast of India–1983–Dr. A.V.S. Murthy.

The most important aspect of the oceanography of the area under study is the prevailing current syctems at the surface levels which change their direction from one season to another.

The effect of the spreading of the high-saline Arabin sea water towards south is neutralised to a large extent by the south-west monsoon rain and theriver runoff.

The sea water temperature within the area under study shows very wide seasonal and spatial fluctuations.

The salinity maximim, characteristic of tropical oceans, was found at depths of 100-150 m. during the north-east monsoon period and between 30-50m. during the south-west monsoon period. The variations in salinity which are mainly brought about the influence of rainfall, river runoff and the prevailing seasonal surface currents are characteristic of surface layersa above the salinity maximum layer.

In general, the shelf waters were-well aerated during the major part of the year except during the south-west monsoon season.

Comparatively low values of vertical stability perameter observed at the surface levels during the winter season could very well be indicative of the existence, duratrion and internsity of the process of sinking.

The process of upwelling is very active in certain localities between Karwar and Cape-comorin. No regularity in the occurrence of upwelling could be observed for any specific locality.

The fishery in the area under study for oil sardine and mackerel commences immediately after the south-west monsoon when the zooplankton biomass at the surface layers reaches the peak in areas of effective upwelling.

The process of upwelling is initiated by the prevailing north-east wind system which removed the surface waters away from the coast there by inducing subsurface waters to move towards comparatively shall-ower depths near the coast.

The vertical time sections for temperature and dissolved oxygen were found to be good indicators of the commencement, intensity and duration of the process of upwelling.

A study on the occurrence, abundance and migrations of oil, sardine, mackerel and anchovy based on observations indicated that factors such as the sea water temperature, dissolved oxygen content, salinity characteritics and plankton biomass at surface levels influenced the abundance and seasonal migrations of these fishes.

## M.S.35. DEVADASN, K.–A comparative study of the muscle proteins of fishes and shell fishes of tropical waters–1983 –Dr. R. Gopakumar.

A comparative study of the composition of the muscle proteins of some commercially important species of fishes and shell fishes of our coast and their changes during preservation and processing was undertaken.

The distribution of the major protein nitrogen fractions in several species of fishes (oil sardine, mackerel and lactarius) and shell fishes (different species of prawns) was studied in detail. The changes in these fractions during stroage of fish/prawn in ice were also followed. When extracted without blending, sarcoplasmic proteins accounting for 25-30% fo the total proteins, could be easily extracted form all fishes and shell fishes.

From the residue after extraction of sarcoplasmic proteins a fairly good percentage of the myofibrillar proteins could be extracted in the case of shell fishes. But in fishes, this extraction was inhibited to a considerable extent. Extraction of sarcoplasmic proteins appeared to modify the myofibrillar proteins in some way, rendering them inextractable. Sarcoplasmic proteins were not affected to any great extent when fish/prawns were stored in ice. But the extractable myofibrillar proteins showed a steady decrease resulting in a corresponding increase in alkali soluble proteins extracted from the residue after extraction of myofibrillar proteins. Stroma remained unaffected throughout, in all cases.

The decreased extraction of myofibrillar proteins in fishes was proved to be due to appreciable amounts of free fatty acids present in the muscle of fishes, as different from prawns.

Solubility with all its limitations, was found to be the best criterion for protein denaturation. Solubility is affected by the ionic strength of the extractants its pH and nature of the ions.

Changes in the muscle protein fractions of oil sardine, mackerel and prawns during quick freezing and subsequent storage at −18°C were also followed by direct extraction with appropriate buffers. With progressive storage, total salt soluble proteins registered a regular fall.

Freshwater fishes were found to have a high content of water soluble proteins. Compared to marine fishes the percentage of salt soluble proteins were also high, probably due to their low fat content.

The effect of phosphates sodium citrate sodium acetate and sugars like glucose etc on the solubility of proteins was also studied.

Acetates, orthophosphate and hexameta phosphate enhanced insolubilization of the protein considerably whereas citrates and gulcose did not have any significiant effect. Sodium tripoly and tetra sodium pyrophosphate could prevent insolubilization to a considerable extent.

Denatruing effect of salt of fish muscle proteins and its possible prevention by alkali phosphates was also studied.

Sodium chloride at 2% concentration itself was found to cause considerably denaturation of proteins as measured by salt solubility. Sodium dihydrogen orthophosphate and hexameta phosphates further enhanced this denaturation, Whereas tripoly and tetra sodium pyrophosphate could prevent denaturation considerably. In these case also the pH of the different phosphate solutions might have played a deciding role. Other possioble mechanisms are also discussed.

## M.S.36. NARENDRAN NAIR, R.– Circulation in the Indian Ocean in Relation to the Monsoon Circulation of the Atmosphere – 1983 – Dr. G.S. Sharma

The forcing function of the wind driven ocean circulation is the curl of the wind stress (vorticity). Since all the parameters related to wind at the surface of the Indian Ocean show considerable time dependance than in other oceans, it is important to study their spatial and temporal variations. This study presents monthly charts of the zonal and meridional components of wind stress, wind stress curl and circulation pattern of surface waters. Monthly charts of the surface currents and winds of the atlas entitled 'Indian Ocean Oceanographic and Meteorological Charts' publishd by the Royal Netherlands Meteorological Institute in 1952 forms the basis of the relevant data used for this study. An area of the Indian Ocean between 36° E and 116° E and from 20° S to its northern land boundary is covered for mapping. Certain salient features observed in the study are given below.

During the southwest monsoon, the curl of the wind stress in the northern hemisphere is positive off the coasts of Somali and Arabia and east coast of India which drives a northerly flow off these coasts. The negative curl off the west coasts of India, Burma and Malayasia drives a southerly flow. During this period, as magnitude of the wind stress curl increases northwards, the strength of the Somali Current increases in the same direction. When the wind stress curl is positive, the circulation off the Somali Coast is northerly and it is southerly when the wind stress curl is negative. In general, cyclonic flow is observed in regions of positive wind stress curl and anticyclonic flow prevails in regions of negative wind stress curl.

The maximum current strength in the Arabian Sea occurs when the intensity of the curl is maximum (May-July). The major anticyclonic circulation comprising of the Monsoon Current, the South Equatorial Current and the Somali Current is most predominant in July and August when the intensity of the negative wind stress curl is maximum. During the northeast monsoon, almost entire northern parts of the Indian Ocean exhibit positive curl field. The zone of negative curl lies approximately south of the equator, and as a result, the major anticyclonic eddy of the southwest monsoon is replaced by a cyclonic eddy in the north and an anticyclonic eddy in the south.

Both zonal and meridional components of the wind stress in the northern hemisphere change from negative to positive during March-April indicating the transition period between the northeast and southwest monsoons. Positive values of the wind stress continue to prevail till August beyond which the transition from southwest to northeast monsoon takes place during September-October. Negative values are predominant during the period November to February indicating conditions of the northeast monsoon.

The main features of the global surface vorticity are anticyclonic vorticity in the middle and subtropical latitudes and cyclonic vorticity in the tropics. But, the vorticity in the Indian Ocean during summer shows considerable variations from the normal pattern. Areas of anticyclonic vorticity cover almost the entire Indian Ocean during the southwest monsoon. These observations demonstrate that the Indian Ocean displays an impressive anomaly of the vorticity distribution and has stronger seasonal changes than any other area of the world ocean.

## M.S. 37. IVY THOMAS – Studies on Chitinoclastic Bacteria of the Coastal zones of Cochin – 1984 – Dr. D. Chandramohan.

For this study 28 sediment samples, 53 water samples, 8 species of prawns and 24 species of fishes were examined over a period of one year. The chitinoclastic bacterial population in these samples varied from undetectable levels to a maximum of 74.44% of the total population. Higher, percentage of chitinoclast were recorded during May when the ambient temperature was comparatively high. Salinity, pH and dissolved oxygen seemed to have no influence on the distribution of chitinoclastic bacteria. Among the samples analysed digestive tract of prawns was found to harbour more chitinoclasts than the shell surface.

Chitinase activity could not be detected in sediment samples and in all the other samples it was in varying levels. No relationship could be observed between the chitinoclastic bacterial population and the chitinase activity in a sample.

Chitinoclastic genera isolated were *Vibrio, Aeromonas, Alcaligenes, Bseudomonas, Bacillus* and members of Enterobacteriaciae. Ammong this *Vibrio* was found to be the domonant genus.

Two strains belonging to *Aeromonas* and *Vibrio* were used for further studies. Both the cultures exhibited maximum growth at 30°c, and at 40°c growth was found to be very much affected, but survived an exposure to this temperature for 60 minutes. The range of pH tolerated by *Aeromonas* was 5-0 to 6.0 and by *Vibrio* 5.0 to 8.0, with their optimum at 5.6 and 7.00 respectively. Both species grew well in media containing 1% NaCl.

The type and initial concentration of chitin were recognized as important cultural conditions for the chitinase production. The study reveals that the chitinase system in both the sprcies are of constituative ones. Maximum chinase production was recorded at 37°c, pH 7.0 and 3.0% NaCl concentrations. The generation time of *Aeromonas* was 1.5 ± .10 hrs. and of *Vibrio* 1.00 ± 0.17 hrs. in chitin media. The maximum degradation rate of chitin for *Vibrio* (5.328 mg/day/$10^{10}$ cells) at 72 hrs. after inoculation. Whereas in the case of *Aeromonas* it was 4.224 mg (day/$10^{10}$ cells).

Properties of partially purified chitinase from both the spicies were studied using colloidal chitinase on subotnates. In both the cases the end product formation was rapid and reached maximum at 40min. and 60min. for *Aeromonas* sp and *Vibrio* sp respectively. Optimum temperature for the enzyme activity was $37^{oc}$. optimum pH was 5.6 and 7 for *Aeromonas* and *Vibrio* respectively. The maximum activity of the chitinase of *Vibrio* sp was recorded at a subrate concentration of 0.21 mg/ml and in *Aeromonas* sp at a concentration of 0.04 mg/ml. Enzymes from both the organisms were stable upto 40 C and they were almost completely inactivated at 70 C. Maximum stability of chitinase of these bacteria was noticed at pH.5.0. Mercury, Copper, Zinc, Calcium and Silver were found to affect the stability of chitinase produced by *Vibrio* compared to that *Aeromonas.*

## M.S. 38. RADHA DEVI, A. – Studies on Cumacea – 1984 – Dr. C.V. Kurian.

The Cumacea are small crustaceans ranging in length from 0.5 mm to 35.0mm having a world wide distribution occurring in the oceans from tidal limit to about 8000m depth. Majority are marine in habitat; a few are found in estuaries and brackish water also. Cumaceans form an important constituent of the food item of the bottom feeding fishes especially during their larval and post-larval stages. They are also known as indicators of hydrographic conditions in the sea.

The thesis is based on few International collections of cumacea from the Indian, Atlantic and pacific oceans taken during 1962-1974 and some collections from the Indian coasts obtained during 1945-1983. The Internationl collections constitute specimens obtained from 25 stations in the Indian Ocean during International Indian Ocean Expedition and deposited in the Smithsonian Institution, Washington, specimens from 6 stations also by 110E from the Indian Ocean and deposited in the Indian Ocean Biological centre at Cochin, specimens from 8 stations in the Philippine Islands collected by S1-Doty Philippine Project, specimens from 21 stations in the Gulf of Mexico received from Mexico Oceanic Sorting centre and materials from 8 stations from Red Sea collected by Israel South Red Sea Expedition. The specimens from the Indian coasts were collected from 29 stations near Visakhapatnam, Tuticorin, Portonovo, Capecomorin, Vizhingam, Trivandrum, Quilon, Purakkad, Cochin, Calicut, Karwar and Laccadive Islands.

The taxonomy of 77 species belonging to 5 families and 20 genera are dealt with; 9 species namely *Eocuma striata, Bodotria platybasis, B. Ocellata, B. cochinensis, pseudocyclaspis granulata, p: mexicansis, Campylaspis minuta, C. robusta* and *Oxyurostylis atlantica* have been described as new species; a new genus *pseudocyclaspis* under the family Bodotriidae has been created for accommodating two species. Besides systematics, distribution of all species collected, vertical and diurnal migration, the biology of the common species and the salinity tolerance of two species are dealt with. Along the Indian coasts, Vizhinjom (South West Coast) and Portonovo (East coast) are the two areas from where large number of cumaceans are obtained. Though cumaceans are generally benthic organisms found in a deposit formed of silty sand, many species are often collected from the surface waters during night in the inshore regions. The different methods of collection of cumacea from the substratum as well as from the surface waters are given. In the Indian region cumacea are abundant along the coastal areas and they show close affinity with those of the West pacific coast especially those from the Gulf of Siam.

## M.S.39. ARUL JAMES, M-Studies on the Microbial Pathogens *Salmonella* and *Vibrio Paraheamolytieus* in selected marine products-1984-Dr. C.T. Samuel.

The study indicated that fresh and marketed samples of selected marine fishes and shellfishes exhibited wide fluctuations of the total viable bacterial population.

The occurrance of *Salmonellae* was more on the surface region of the fin fishes and the shell-fishes than on the gills and in the stomach regions. In the case of *V. parahaemolyticus* higher incidences were also found on the surface and in the stomach regions.

Higher values were exhibited in the prawns (Penseus indicus) and Crab (Scylla serrata) both in freshly harvested condition and in retail markets.

Both referigerated (3°-6°C) and frozen (-20°C) temperatures registered sizeable proportion of reduction of counts of *Salmonella* and *V. parahaemolyticus* in liquid broths and homogenates of fin fishes and prawns crabs when artificially inoculated.

The study of injury and death during freezing process, showed that broths indicated higher percentages of injury and death of Salmonella strains studied than in the homogenates of fish and shellfishes.

The study indicated that the various *Salmonella* serotypes survived when exposed to higher temperatures of 50° to 60°C for 15 min to 30 minutes.

It was found that *V. parahaemolyticus* organisms were more heat sensitive than *Salmonella*.

In this investigation, the isolated strains of *V. parahaemolyticus* showed lesser injury when the salt concentration increased from 0.5% to 7.5% and furner the injured cells recovered within two to three hours when placed in the noninhibitory media. The recovery was independent on the protein, Ribonucleic acid and deoxy ribonucleic acid synthesis.

All the *Salmonella* organisms were sensitive to ampicillin Nalidixix acid, and polymyxin B. *V. parahaemolyticus* cultures also showed variable sensitivity to different antibiotics. 88% were sensitive to chloramphenicol, 57.9% to neomycin. 61.7% to Nalidixic acid, 82.8% to streptomucin and 50.6% to polymyxin B.

## M.S.40. RADHAKRISHNAN NAIR, P.N.-Studies on the Systematics, Biology and Fishery of Rainbow Sardines, Dussumieria SPP., from Indian Waters -1984- Dr. P.V. Ramachandran Nair.

The present study deals with the systematics, biology and fishery of rainbow sardines of India belonging to the remus *Inssumieria* of the family Dussumieriidae with special reference to *Dussumieria acuta*.

The systematic position of the species of *Dussumieria* has been reviewed. Samples of rainbow saridines were collected from different centres along the southern coast of India and were analysed morphometrically and meristically, employing standard statistical methods, and the existence of two species, viz. *D. acuta* and *D. hasseltii* under the genus has been established beyond doubt.

Diurnal variation in feeding habit was noticed in *D. acuta*.

A comparison of the food items of *D. acuta* from the Gulf of Mannar and the Palk Bay indicated that the major food constituents were essentially the same in both these localities.

The gonads in *D. acuta* are bilobed and distinctly asymmetrical in their size, the right lobe being bigger than the left lobe.

The spawning season of *D. acuta* was also acertained by estimating the gonado-somatic index.

Analysis of coveriance showed that among the Dracuta males and females of both the years there were no significant variations either in slope or elevation.

The catch data of rainbow sardine at Mandapam area, as estimated by the author, for a period of 7 years from April 1969 to December 1975 showed an annual average of 9415 Kg.

## M.S.41. CHANDRIKA, V.-Studies on the Ecophysiology of some heterotrophic and Indicator bacteria in the marine environments of Kerala-1984-Dr. P.V. Ramachandran Nair.

The thesis entitled "Studies on the eco-physiology of heterotrophic and indicator bacteria in the marine environments of Kerala" embodies the results of an investigation carried out by the candidate at the Central Marine Fisheries Research Institute, Cochin. It is presentedd under 4 chapters in two parts (Parts A & B) and includes 6 sections. The material for the study was collected in the Cochin backwater during April 1972 to February 1973, March 1974 to February 1975, July 1975 to June 1976 and in the ishore area during January to October, 1978 and an account of the heterotropic and indicator bacteria are given with intensity charts and tables.

Samples from all the stations contained significant quantities of heterotrophs (Part A, Section I) and faecal pollution indicators (Section II). Maximum number of heterotrophic bacteria was observed during the postmonsoon period. The total counts betwen one station and the other did not vary as much as the counts between months did. The distribution was characterised by overdispersion. During 1972-73 in all the stations except the fourth the minimum heterotrophs (Total counts) were recorded during the monsoon period. Minimum counts were observed during the premonsoon period, with an increasing trend from the premonsoon to postmonsoon seasons. Maximum counts were recorded during monsoon months during 1974-75. No significant difference was noted in the total plate count between stations, months and regions. Seasonal variations in sea water was meagre during 1975-76, whereas in sediments variations were prominent during monsoon in Station I - near the mouth of the sewage effluent of Cochin City and in postmonsoon at Station II in the Mattancherry Channel and Station III near barmouth.

In total 8 genera namely *Alcaligenes, Pseudomonas, Vibrio, Aeromonas, Photobacterium, Flavobacterium, Micrococci* and *Bacillus* were the main constituent of bacterioplankon in the surface water as well as sediments. *Micrococci* and *Bacillus* were encountered more in sediment than in water. Bacterial species varied seasonally but proteolytic, lipolytic and amylolytic activity appeared independent of the season. Eemzymatic activity was not a reflection of the bacterial genera.

Estimation of numerical abundance of four indicators of bacterial pollution and their variation in seasonal occurrence with environmental parameters showed that the coliform counts differed significantly between stations, between months and between regions. The presence of coliform was more in sediment than in water. *E. coli* counts showed significant difference between stations and between months. Faecal streptococci showed significant difference between stations, months and regions. The count was significantly high in backwater than in offshore samples. Faecal index showed significant difference between stations and between months. Station near the sewage outlet was having significantly higher faecal index to other stations both in sea water and sediment indicating predominance of animal waste in mixed pollution in this area.

The third section includes studies on zymogenous heterotrophic microbes (amylolytic, gelatinolytic, lipolytic, chitinolytic, caseinolytic ureolytic population) association with *Salvinia molesta* in water and sediment from 10, 20 and 30 metres in the inshore environment of Cochin during 1978. Sediment/water ratio of zymogenous microbes were constructed and increased rate of *Salvinia* deposits resulted in a decline in the sediment/water ratio of all the zymogenous micro-organisms. The depth range of 10 to 20 m appeared to be more dynamic and productive investigated in the inshore region.

A comparative study of 43 marine bacteria isolated from 3 beaches near Trivandrum and 60 human bacteria from clinical speciments fromed the 1st section under Part B. Glucose fermentation was very high in human strains whereas citrate utilisation was very high in marine bacteria. $H_2S$ production was very low in marine isolates as well as in human bacteria but Indole production was high in strains isolated from marine environment than in human isolates.

*In vitro* study of antibiotic sensitivity of the marine bacteria (Part B - Section II) and human strains isolated from clinical speciments showed multiple drug resistance than resistance to one or two drugs among marine bacteria. 100% Penicillin resistance was encountered in isolates from marine environment whereas isolates from human source showed 100% resistance to 3 antibiotics like Penicillin, Erythromycin and Cephoron. A higher percentage of resistant organisms were notedd among human pathogens ranging from 50% to 60% while the resistant rate was only 34% among marine bacteria. Out of 3 concentrations of 10 different antibiotics used, the lower concentration showed higher rate of resistance with most of the Gram-negative bacteria from clinical speciments though much differentiation in sensitivity was not noted between middle and higher concentration.

About 230 *E. coli* (Type I) isolated from the samples during 1975-76 were subjected to preliminary serological determination and seven *E. coli* '0' serotypes were encountered and serotypes 026, 055, 086, 0111, 0119, 0127 and 0128 were identified as enteropathic *E. coli* (Part B, Section III). 75% of the 0111 *E coli* serotype was in agglutenable in '0' antiserum unless first heated at 100°C. Except '0' serotype 026 all the other serotypes were isolated also from sea water. Faecal index was constructed with the ratio of faecal coliform and faecal streptococci and the relationship between total bacterial population and faecal index was found significant.

Most of the isolates encountered in the three beaches near Trivandrum, (Shankumugham, Kovalam and Vizhinjam) belong to *Pseudomonas* sp. All the isolates were non-pigment producers except 2 species of *Pseudomonas*. Maximum isolates including enterobacteria were isolated from Shankumugham beach water. Based on *E. coli* distribution the Vizhinjam beach was considered to be most polluted of all the beaches studied. Eventhough Vizhinjam beach possessed more *E. coli* than Shankumugham and Kovalam, the Shankumugham beach possessd more antibiotic resistant microbes distinct from that of other sites. The high rate of incidence of multiple drug resistant organisms in the littoral waters of Trivandrum indicated the possibility of R-factor mediated drug-resistant bacteria also in this environment, which could transfer their resistance to other gram-negative pathogens. Such transfer would create a pathogen with formidable capabilities possessing enhanced infectivity and virulence. All these results suggest that the marine environments of Kerala can also be identified as potential reservoir of multiple drug resistant isolates harbouring R-Plasmid which are involved in inactivating the lethal action of drugs on bacterial strains.

## M.S.42. BALCHAND, A.N.–Studies on the Dynamics and Water Quality of the Muvattupuzha River in relation to Effluent Discharge–1984–Dr. P.N.K. Nambisan and Dr. P.G. Kurup.

Tropical river-estuarine-nearshore system has been found to function in a rhythm quite different from those of mid & upper latitudes. As such, the natural geochemical cycles best reflect the dominant features to include the annual transport of rich silt laden particulates across the fresh-estuarine-marine waters. A comprehensive programme devoted to the study of chemical aspects of these natural systems would serve to full fill numerous scienific objectives of the complex ecosystem Lately urban agglomeration, industrial expansion, varied agricultural practises have influencedd the built-in nature of these regimes, studies on which, to a large extent is a measure of environmental quality/quantity changes. The thesis accounts for the study of a tropical river-estuarine system (water quality & dynamics) before and after receiving effluent discharges from a pulp-paper factory. (Period of field survey Oct. 1980 to Sept. 1982).

The south-central parts of state of Kerala comprises of two large river basins of Periyar R and Muvattupuzha R. Since late 1976, water from Periyar R. catchment area is being diverted into Muvattupuzha R. through Idukki dam and Moolamattom power station. The river water serves all the requirements of the locality and is utilised for agriculture, domestic purposes, recreation etc. A 400-tonnes per day newsprint factory is located 12.5 km from Muvattupuzha river mouth, designed to discharge its effluent into the river.

The water quality prior to effluent discharges indicated good potable water of high standards. The water is nearly saturatd with Oxygen (DO-6.0-11.5 mg/1) and pH lies within 6.85 to 7.20. The amount of suspended solids were low (2-30 mg/1) and BOD ranged between 0.5 and 3.0 mg/1. The content of nutrients were also low and mercury in river water was 0.0005 mg/1.

The factory discharged effluents: 0.65-1.0 $m^3$/sec, of DO 0.5-3.5 m1/1, pH 4.5-8.7, suspended solids content being 80-250 mg/1 and BOD ranging between 10-5000 mg/1. The river water after receiving the newsprint effluents indicated pH 6.0-8.3, suspended solids 50-140 mg/1, BOD 1.5-50 mg/1. The organic carbon content of sediments collected from downstream pools were high (1.5-9.0%) compared to values (0.5-1.4%) before waste dischrge. Large quantities of nutrients were also detected in the river water. Persisting presence of mercury in levels ranging from 0.0012-0.05 mg/1 was observed during effluent discharges.

Studies on the physiography and flow characteristics reveal that the discharge in Muvattupuzha river has increased from 4-7 $m^3$/sec to 50 $m^3$/sec in dry season since the discharge of tail race waters. The climatic conditions favour a peak discharge (400 $m^3$/sec) during June-July months coinciding with the peak south-west monsoon. Studies on the interaction between tides and river flow indicate that the lower river reach of about 30 km is affected by tides, by way of periodic rise and fall of water level with no upstream currents. A minimum river discharge of 30$m^3$/sec was worked out statistically for a typical tide just to prevent upstream flow at effluent cutfall point. The implications of a forthcoming water resource project (Malankara Balancing Reservoir) are discussed in the light of the tidal behaviour of the river.

The dispersion pattern at the effluent outfall region was studied by conducting two tracer experiments. The results indicated that the dispersion was not effective enough to cause the required dilution of the effluents. This was observed to be true in the actual situation. The location of outfall has drawbacks with regard to the upstream slope, backcurrents and curvature effect apart from the deficiency in design of the diffuser part.

The organic loading capacity of the river was calculated using a modified version of Streeter-Phelps formula.

$$L_t = L_O 10\text{-}(K_1 + K_3)t$$

$$D_t = \frac{K_1 L_O}{K_2 - (K_1 + K_3)} [10^{-}(K_1 + K_3)t - 10^{-}K_2t] + D_O 10^{-}K_2t$$

Where $L_O$ = Initial BOD (mg/1), $L_t$ = Ultimate BOD after time 't' (mg/1), $D_O$ = Initial DO deficit (deficit = saturation DO value - observed DO) (mg/1), $D_t$ = DO deficit after time 't' (mg/1), t = time (seconds or days), $K_1$ = Deoxygenation co-efficient/day, $K_2$ = Reaeration co-efficient/day and $K_3$ = +ve values for rate of removal of BOD due to sedimentation or volatilization/day and -ve values for rate of addition of BOD due to scouring of bottom deposits/day.

The profiles using Oxygen Sag curves were derived for different BOD loads and were found comparable with observed values. Under present conditions, in order to maintain the entire stretch of the river downstream of outfall well above the tolerance limit for DO (3 mg/1 or 40% of saturation value, whichever is higher) a value of BOD 300 mg/1 has been estimated as the maximum assimilative capacity for this river.

An impending problem of pollution is connected to the untreated sludge disposed in a low field, flooding during monsoon. The sludge contains cooling pond waste, organic matter like fibre, wood chips, cinder ash, lime mud etc. which may find way into the neighbouring agricultural fields and contaminate ground water. The overall results indicate that the river water downstream of the outfall is polluted rendering water unsuitable for drinking, bathing, recreation and agricultural purposes. The pollution problems may further aggravate, once the Malankara balancing reservoir diverts nearly 2/3rd discharge in the river causing active tidal intrusions upstream of the outfall.

## M.S.43. HARIDAS, P.–Zooplankton studies in the Cochin Environs–1984–Dr. T.S.S. Rao and Dr. M. Krishnan Kutty.

Detailed studies on the hydrographical features, distribution patterns of estuarine zooplankton, variations in their abundance, species succession, dominance, community structure, and diversity in the Cochin back water system have been compared with other seven estuaries along the Kerala coast namely Veli, Thottappilly, Neendakara, Kallai, Baypore, Korapuzha and Mahe based on year round investigations during 1978.

The hydrographical conditions of all the estuaries except Veli and Thottappilly in general are similar with salinity showing wide variations over the year depending on the onset and intensity of monsoon. The conditions at the estuarine mouth ranged from almost marine to fresh water during different seasons except at Neendakara where the water column remained slightly saline even during the peak monsoon. Steep vertical gradients in salinity, temperature, and oxygen noticed in the Cochin backwaters during monsoon were less pronounced in other estuaries especially Neendakara and Mahe.

Veli and Thottappilly lakes differed from other estuaries in their hydrobiological aspects because of their limited connection to the sea. While Thottappilly remained practically fresh water during most of the year, the water at the bottom was saline at Veli during premonsoon and post monsoon. This in the absence of a free connection with the sea could be explained partly by the dynamics of coastal aquifer and also partly by spill over during intensive wave action.

Zooplankton biomass and total zooplankton counts varied significantly between seasons and estuaries, Cochin recording the highest value followed by Korapuzha and Kallai. Seventy three species were identified from these estuaries. Maximum number was recorded from Cochin. Neendakara rankedd next in species richness. Copepoda was the most abundant group followed by zoea larvae and sergestidae.

Carnivorous forms like Hydromedusae, Ctenophora and Chaetognatha through only a small fraction of the total numbers exerted profound influence on other groups especially copepoda.

Among Copepoda families Acartiidae, Paracalanidae and Pseudodiaptomidae formed the bulk of the population constituting 85 to 90% of the total copepods. *Acartia centrura* emerged as the most common and abundant species in these estuaries.

Among the truely estuarine species three clines - high saline, medium saline and low saline - were recognised. Veli and Thottappilly lakes had a mixed assemblage of high and low saline copepod fauna.

Phytoplankton, detritus and associated bacterial load form the main food source for the zooplankton. The energy transfer from primary to secondary trophic level is low in Cochin backwaters.

The successional sequence after the monsoonal wash out could be seen from their numerical abundance during high saline period. Although the broad scheme of succession was similar, individual variation did exist in different estuaries.

Diversity was high in the estuaries during high saline period when conditions were more stable. Productivity and spatial heterogenity being of little consequence it is speculated that lack of stability leads to lower diversity in estuaries.

## M.S.44. AMMINI JOSEPH–Culture and growth Kinetics of Selected Manoplankters–1984–Dr. P.V. Ramachandran Nair

The present study on nanoplankton is based on the isolation and development of unialgal cultures from the inshore waters of Cochin, characterization of their growth, assimilation products, eco-physiology and evaluation of nutritional quality.

Taxonomic description of thirteen species of nanoplankters in the Cochin estuarine and coastal regions have been given. Of these two were isolated during the period of this investigation. They are *Chromulina freiburgensis* Doflein and *Isochrysis galbana* Parke *forma nova* (referred as *I. galbana* (C.s.) and these are new records for the Indian waters.

The amount of protein, carbohydrate and lipid of *C. freiburgensis*, *I. galbana* (C.s.), *S. salina* and *I. gracilis* was estimated at different phases of growth in culture.

The rate of carbon fixation by the nanoplankters was found to be affected by the density of culture. The flagellates had a lower optimal saturation density i.e. 6–10 x $10^5$ cells/ml compared to cultures of *Synechocystis salina* for which the rate of 14C uptake increased with cell concentration upto 175 x $10^5$ cells/ml after which there was decline. This difference could be related to the relative volume of the two species.

The rate of growth of *C. freiburgensis*, *I. galbana* (C.s.) and *S. salina* was studied with respect to varying concentrations of nitrate and phosphate in the culture medium and the nutrient requirement of these species were defined in terms of half-saturation constants for growth.

From the nutrients kinetic studies of the flagellates it was evident that *C. freiburgensis* has better chances of survival than *I. galbana* (C.s.) in culture.

The acceptability of the two species *C. freiburgensis* Doflein and *I. galbana* (C.s.) to the molluscan larvae was tested. Newly hatched larvae of *Crassostrea madrasensis* fed separately with *C. freiburgensis* and *I. galbana* (C.s.) settled as spat in 17 and 19 days respectively. The results of the experiment showed that these flagellates were not only acceptable to the larve but also induced higher growth rate and larvel survival compared to control feed i.e. *I. galbana* Parke, the temperate water strain that is widely in use in hatcheries. *C. freiburgensis* seems to be the more potent species for development as live-food in oyster hatcheries.

## M.S.45. PREMALATHA, P.–Studies on the larvae of carangid fishes along the south west coast of India–1984–Dr. C.V. KURIAN

Studies on the larvae of carangid fishes along the south west coast of India were carried out based on the regular plankton collections of the UNDP/FAO/Pelagic Fishery Project during the period 1971 to 1975. The area of collection extended from Ratnagiri to Tuticorin between the latitude 17°00'N to 07°00'N and longitude 71°'E to 79°30'E. Regular and systematic sampling were made along fixed profiles mostly from shelf waters and some beyond the continental shelf. The plankton collections were made with standard sampling gears viz. Bongo 20 and Bongo 60 cm with a mesh size of 0.505 mm from the research vessels 'Restrelliger' and 'Sardinella'.

Out of the 1284 plankton stations worked, 531 samples contained 3284 carangid larvae and this formed about 7% of the total larval biomass. Major emphasis were given to the study of early developmental stages and distribution and abundance in relation to hydrographic parameters. Early developmental stages of six species viz. *Megalaspis cordyla, Decapterus dayi, Alepes kalla, Alectis ciliaris. A. indicus* and *Atropus atropus* which were of commercial importance along the south west coast of India were studied in detail. The identification of the larvae were mainly based on meristic and morphometric of the adults. Juvenile carangids obtained in the pelagic trawls were also utilised for further confirmation of the species.

**Megalaspis cordyla.** Out of 660 number of larvae and post-larvae, 24 stages ranging from 2.2 mm to 40.0 mm were studied in detail.

**Decapterus dayi.** Out of 656 number of different stages 21 stages from 2.2 mm to 40.0 mm were described in detail.

**Alepes kalla.** 320 larvae andd post-larvae were obtained for the present study, 20 different stages from 2.0 mm to 40.0 mm were studied in detail.

**Alectis ciliaris.** 48 different stages ranging from 4.0 mm to 8.0 mm were obtained for the present study.

**Alectis indicus.** 35 different stages from 2.7 mm to 7.0 mm were studied in detail.

**Atropus atropus.** 41 different stages from 3.4 mm to 8.3 mm were studied in detail.

The quantitative study thrown sufficient light on the distribution and abundance pattern of carangid larvae as a whole and different species separately. The seasonal distribution and abundance of carangid larvae and direct correlation with the hydrographic parameters of the area under study. It had also been observed that the distribution of the larvae were directly related to upwelling and plankton production. In general, there is a gradual increase in abundance of larvae from May onwards with a peak in July, which appeared to be in correlation with the south west monsoon. But there are variations in individual species. In the case of *M.cordyla* the peak season was in the month of June, while *D. dayi* showed a bimodal peak-one in June and other in Septermber-October months. The larvae of *A. kalla* were more abundant from July to October, showing a tendency of prolonged breeding season. The larvae of *A. ciliaris* were found maximum during March-April period. The peak season for *A. indicus* was observed during February - April months. For u *A. atropus* May-June months showed highest abundance.

The spatial distribution showed that carangid larvae in general were delineated into two areas as north and south. Larval abundance was more towards the southern region between Cochin and Cape Comorin, than at Calicut to Ratnagiri area. Larvae of *M. cordyla* were found more towards Calicut and Karwar regions, whereas larvae of *D. dayi* occurrd more frequently in the southern areas. The larvae of *A. kalla* showed maximum occcurrence in Cochin and Kasargod areas. In the case of *A. ciliaris* the larval occurrence was maximum at Quilon and Ratnagiri. Larvae of *A. indicus* showed maximum occurrence towards north, most abundant being at Calicut. Larvae of *A. atropus* showed maximum abundance at Cochin and Cape Comorin areas. The observation on horizontal distribution showed the maximum larval concentration along the mid shelf waters. Analysis of day and night collections showed that carangid larvae were present more in the day collections. Of the six species studied, three of them namely *M. cordyla, A. kalla,* and *A. atropus* were more in the day collections, whereas *D. dayi, A. ciliaris* and *A. indicus* were obtained more in the night collections. Since carangid fishes form an important component in the total marine landings in India, the need for its proper exploitation and utilisation is also discussed briefly.

### M.S.46. SIVADAS, T.K.–Development of a portable Composite Equipment for Fishery Hydrographic Investigations–1984– Dr. C.T. Samuel.

This thesis reports on the details of the works done to develop a complete system for acquisition of the important marine environmental parameters namely, current, current direction, salinity, temperature and depth. It encompasses transducers, signal conditioners display arrangements and remote controlled multiplexer which constitue the system. The various associated instrumentation and environmental requisites and problems have been discussed and solved to considerable extend. The design and development features of this composite system includes an integrated approach in order to make the final equipment to be simple, inexpensive and easy for operation from small and large boats.

Out of the 5 sensors, that of current salinity and depth are quite noval types with specific advantages. The environmental effects have been eliminated to the required extend.

The instrumentation problem associated with extension of cable has been solved rendering the system flexible for alteration of cable length for different requirements.

The reliability of the various sensors, signal conditioners and multiplexers developed for the equipment and other associated methods for field checking, compensation for environmental effects etc. have been further established with the successful development of several descrete instruments and large automatic data acquisition systems. Many such instruments based on the same technology are under operation in different conditions including the most hostile and hazardous environment on the floating dynamically stabilized oil rig SEDCO 445 operated in Bay of Bengal for oil and Natural Gas Commission.

The technology developed is expected to go a far way in our marine exploratory programmes providing useful data for various activities connected with the exploration and exploitations of the living and non-living resources of the ocean, and other engineering constructions.

### M.S. 47. SATHEESCHANDRA SHENOY, S.–Studies on the. Littoral Processes in Relation to Stability of Beaches Around Cochin–1984–Dr. P.G. Kurup.

The results of studies carried out on the dynamical effects of environmental parameters on the shoreline processes along the beaches around Cochin are presented in this thesis.

The deep water wave characteristics and their monthly variations have been obtained from the analysis of available data and presented as wave roses in Chapter 2.

It has been found that during fair weather season low, long period swells are predominant while the southwest monsoon season is characterized by the predominance of high and steep low period waves.

The wave refraction studies indicated greater amplification of the waves as they propagate ashore particularly from the southerly compared to those from the northerly quadrants.

While making a comparative study of the predicted wave heights at 2 m isobath with the observed field data on breakers, the presence of large-scale anomalies have been found.

The sediments of beaches in general fall in the medium to fine sand-size limits and reflect a low energy environment.

The total quantum of sediment in transit has been estimated to be 9.5 x $10^6$m$^3$ during rough weather season and 7 x $10^6$m$^3$ during fair weather season.

The erosional and depositional tendencies of the beaches have been estimated through beach profile surveys

The beaches exposed to wave action presented cyclic changes showing erosion during southwest monsoon season and accretion during rest of the year.

The beaches along the shore from Azhikode to Anthakaranazhi are comparatively low energy environments and the erosion, though considerable, takes place for a short period during the year coinciding with the wind and wave climates of the southwest monsoon season.

### M.S.48. NEELAKANDAN NAMBOODIRIPAD, K.S.–Studies on the Propogation of Errors in Physical Oceanographic Computations–1984–Dr. P.G. Kurup

Measurement of independent variables at sea is subject to random errors. These errors get propogated, through the series of computational procedures, into the final derived results. The magnitude of errors in the final results may, at times, of such magnitude as to vitiate the results themselves. This study is an attempt to examine the limit of errors contained in the basic data and the magnitude of error component in the derived results of dynamical oceanography.

After discussing the general theory of errors relevant in the context of studies on the propogation of errors in physical oceanographic computations, an expression is derived for the computations of standard deviation of a normal error distribution representing the distribution of errors in the summation of a large number of values, when only the maximum individual error is known.

Errors in the measurement of independent oceanographic variables, namely, temperature, pressure and salinity are then discussed. It is shown that the magnitudes of total errors, both in the protected and unprotected reversing thermometer readings, are ±0.01°C upto a depth of 200 m and ±0.02°C below 200 m depth. The corresponding total errors in the depth computations are shown to be ±2 m and ±4 m respectively. It is also shows that the total error in the determination of salinity by the method of titration and by the method of conductivity ratio measurement are ±0.04% and ±0.02% respectively.

The errors committed in the measurement of independent Oceanographic variables are propogated, through the computational procedures, into the computed values of dependent oceanographic variables, namely, sigma-t and specific volume anomally. It is shown that maximum error in the computed values of sigma-t, when salinity is determined by the method of titration and when it is determined by the method of conductivity ratio measurement, are ±0.03 and ±0.02 respectively. The corresponding errors in the computation of specific volume anomally are 3 cl/ton and 2 cl/ton respectively.

The errors propogated into the computed values of derived quantities, namely, dynamic height anomaly of isobaric surfaces and relative currents, are then discussed. It is shown that deeper the selected reference surface, larger is the magnitude of error in the determination of dynamic height anamaly of isobaric surfaces. It is also shown that the magnitude of error in the computed relative current is directly proportional to the error in the determination of difference in dynamic height anomalies and inversely proportional both to the distance between the two stations and the sine of latidude angle.

After critically discussing different methods for the identification of a level of no motion, a more dependable method for the negigibly small, by the application of shtokman's density model for th oceanic mass field, is discussed.

The existing methods for the extension of selected zero reference surface to the shallow regions of the ocean for the purpose of current computation are then critically examined. A new method for the same purpose which consists in the extrapolation of dynamic height anomaly of the isobaric surface, which represents the deepest sampling depth at the shallow station, is proposed and discussed. It is shows that this method is free from the objection raised in connection with the existing methods.

A method of smoothening of the dynamic relief of an isobaric surface, in a profile, within certain error limits is then discussed. It is shown that the smoothened values of the dynamic height anomalies of isobaric surface will give a more dependable picture of the oceanic circulation pattern. The reduction of computed current relative to any reference surface to the zero reference surface, arrived at by the use of Shtokman's density model to the oceanic mass field, is then discussed.

## M.S.49. SATHYANARAYANA MURTHY, A-Studies on storm surges and sea level variations along the east coast of India-1984-Dr. G.S. Sharma

About 15% of the tropical cyclones in the world originate in the Bay of Bengal and the Arabian Sea in an year which means to nearly 10 to 15 Cyclones cross the coast of India and Bangladesh every year. The dangerous part of the cyclones is the development of surge while they cross the coast line, particularly in the low lying areas. Loss of life and other kinds of damages can be minimised only if the magnitude and approximate time and place of occurrence of the surge could be predicted at least a day in advance. Therefore, an attempt was made to study the storm surges generated by the cyclones that strike the east coast of India and suggest a method of predicting them through nomograms.

This thesis is an outcome of some of the investigations carried out on storm surges and sea level variations along east coast of India. Its principal aim is to identify the areas that are maximum affected by the cyclones and suggest a method by which the surge of an impinging cyclone can be predicted with the knowledge of the pressure drop, the approximate size and the angle of incidence of a cyclone. The aim is achieved by estimating the wind induced surge for four cases of past cyclones that attacked the east coast of India and comparing the estimates with the computed surges for verification. For prediction of surgs at five important places (Nagapatnam, Madras, Masulipatnam, Visakhapatnam and Paradip) nomograms that represent surge height versus pressure fall with different radii of curvature of cyclones are prepared. These nomograms are prepared at two angles of incidence (90° and 135° from north) which are the two usual approaches of the cyclone. As the surge development depends on curvature of the coast line and bathymetry for the same cyclone, two different surges are developed by the same cyclone at two different angles of approach. The wind induced surge is computed from winds estimated using the gradient wind equation and actual bathymetry along the path of the cyclone. The pressure gradient is obtained from synoptic maps. In order to assess qualitatively the time of occurrence of the peak surge and its order of magnitude, residual sea level is computed by subtracting the hourly astronomical tide taken from the tide tables, from the recorded tide at the nearest tide gauge station of the landfall.

The mean seasonal and secular sea levels are also presented using the sea level data supplied by the Permanent Service to Sea Level, I.O.S, Bidston, U.K. The total sea level rise is estimated as the combined effect of wind surge, barometric forcing, the prevailing mean sea level and resonance due to phase of the tide.

The thesis comprises of six chapters. First chapter consists of introduction, description of the area and treatment of the data. Second chapter deals with the case studies of storm surges along the east coast of India. Third chapter discusses sea level variations along east coast of India. Fourth one presents nomograms. The last two chapters contain discussion, summary and conclusions respectively. The thesis carries a text of 141 pages with 71 figures and IX tables.

## M.S.50. AJITHAKUMAR, B.S.–Reproductive Physiology of Indian Species of the Genus Perna–1984–Dr. K. Alagar Swamy.

The reproductive physiology of the two species of Indian sea mussels, namely the brown mussel *Perna indica* and the green mussel *P. viridis*, has been investigated by the comprehensive approach to the problem. The major aspects of the study include ecophysiology of reproduction linking up the annual reproductive cycle of the animals with the ecological conditions of the natural mussel beds, biochemical and histochemical changes associated with reproduction, and the neurosecretory cycle in synchrony with the reproductive cycle.

Data on temperature, salinity, dissolved oxygen, turbidity, phytoplankton production and rainfall have been presented for both the study areas.

*Perna indica* was in reproductive phase during February to September and in the resting (vegetative) phase from October to January. Sex differentiation and gametogenesis commenced in February and active gametogenesis was noticed in March and April.

Spawning took place from September to November with a peak in October in the primary reproductive cycle and was observevwd from January to March with a peak in March in the secondary cycle.

The secondary spawning of *P. viridis* is associated with higher temperatures but the spawning is incomplete and partial.

Rainfall, through its effect on lowering the temperature and salinity, appeared to influence the different processes of reproduction.

Reproduction also showed a high degree of correlation with availability of food.

Localised pollution of coastal waters due to coconut husk retting near Elathur had an effect on the reproductive potential of *P. viridis*.

Biochemical studies on *P. indica* and *P. viridis* revealed that, the composition varied with the stages of maturity and also seasonally.

The gonad of the mussels was observed to be of glycolipoprotein in nature.

The neurosecretory cells (NSC) of a single type (pyriform) have been observed in the cerebral and visceral ganglia of *P. indica* and *P. viridis*.

Experimental evidence has been obtained on the role of neurosecretion in spawning of *P. indica* and *P. viridis* through extirpation of the ganglia of the central nervous system.

## M.S.51. UNNIKRISHNAN NAIR, N.–Studies on the Backwater Oyster Crassostrea madrasensis (Preston) of the Cochin Harbour–1985–Dr. N. Balakrishnan Nair.

1. A detailed study of the hydrography of the Cochin Backwaters, the habitat of *Crassostrea madrasensis* has been carried out. Data pertaining to air temperature, water temperature, salinity, dissolved oxygen, turbidity and rainfall have been collected and presented. The temperature fluctuation was in the range of 5°C only and that of salinity between 1.1% and 32.9%. Fairly steady salinity has been recorded during the pre-monsoon period (February to May) and distinct stratification during the monsoon period (June-September). Dissolved oxygen varied between 2.5 ml/1 and 6.5 m1/1. Turbidity was highest in June (27.9.p.p.m.) and minimum 10.2 p.p.m.) in March.
2. A detailed study on marine biofouling in the Cochin Backwaters has been made with special reference to primary film, settlement and growth of the fouling organisms such as hydroids, bryozoans, tube-dwelling polychaetes, barnacles and modiolus.
3. An account of the settlement of *C. madrasensis* in the Cochin Backwaters is presented. *C. madrasensis* a wide distribution in the backwaters. In the five stations investigated, no settlement of *C. madrasensis* was observed during the monsoon period owing to reduced salinity. Settlement in general was confined to the late post-monsoon period and thoroughout the pre-monsoon period.
4. Height-length studies in *C. madrasensis* revealed on exponential trend in the form $H = AL^B$. Larger deviations in height for longer oysters were observed. For oysters below 3.5 cm in height, height and length approximated. The ratio changed for oysters of 8 cm and above in height. Height-depth relation also showed an exponential relation in the form $H = AD^B$. The variations in height did not bring about corresponding variations in depth. The frequency distribution of the index of shape also showed that height and width are not directly proportional to increase in length.
5. The relation of weight to height, length and depth was examined by a multiple regression. t-tests showed that the regression co-efficients were significantly different from zero, suggesting that increase in height, length and breadth contributed to the weight in *C. madrasensis*. Partial regression co-efficients showed that weight is influenced by height, length and depth in their order of preference.
6. Condition index and percentage edibility for the total oyster populations were worked out Condition index and percentage edibility showed a similar trend for the total population and also for males, females and indeterminates. Maximum condition index and percentage edibility were noticed during October which declined and reached the lowest in February-March. From April, it showed steady increase reaching the maximum again in October.
7. Studies on age and growth showed faster growth rate in *C. madrasensis* inhabiting the Cochin Backwaters compared to those reported form Madras. Salinity fluctuations and alteration of meschaline and polyhaline condition at the Cochin Harbour influenced the growth in *C. madrasensis*. Growth was determined by the progression of model height during different months. The maximum size which oysters can attain ($L \propto$ ) and catabolism coefficient K, ($\log_e \tan \propto$ ) were determined by Ford-Walford technique. The theoretical time at which oyster height is zero ($t_o$) was determined by plotting $\log_e (L \propto - 1_t)$ on t. From this, it was read as the time relating to logL. $L \propto$ was found to be 21 cm.
8. Biochemical studies have shown similar trend in the fluctuation of water content in male and female oysters. A definite pattern in the distribution of protein was noticed. It showed an inverse relation to glycogen. A definite shift in the values of protein corresponding to the reproductive phase of oysters was noticed. Fat content was low during December to May with peaks in September in both the sexes. Ash also showed a trend similar to protein.
9. Trace metal load of cadmium, copper, iron, manganese, zinc and mercury was estimated. The study has shown that heavy metal load in *C. madrasensis*

10. A brief account is furnished of the associates and their ecology. The parasites include, the boring sponge *cliona*, the polychaete *Polidora ciliata* and the tramatode *Bucephalus* sp. Several species of bryozoans such as *Electra bengalensis, Alderina arabianensis, Schizoporella cochinensis, Nolella paupensis, Bowerbankia impriata, Electra crustulenta, Victorella pavida* and tubicolous polychaetes such as *Hydroids norvegica, Mercierella enigmatica* and crustaceans such as *Balanus amphitnite, Corophium triaenonyx, Sphaeroma walkeri* were recorded as associates. The formation of pearl in one instance has also been recorded in this edible oyster. The results of the present studies are discussd in detail with earlier work on oysters from India and abroad.

## M.S.52. MURALEEDHARAN, P.M.–Studies on the equatorial undercurrent in the Indian Ocean–1985–Dr. G.S. Sharma

The main objective of the thesis is to carry out a detailed investigation of the seasonal, latitudinal and longitudinal variation of the Equatorial Undercurrent in the Indian Ocean and also the Equatorial jet, through mapping the vertical distribution of the oceanographic properties across the equator along various longitudes for all the months of an year, between 5° N and 5° S. Zonal flux is computed by adopting the method of Montgomery and Stroup (1962), in order to have a quantitative variation of the Equatorial Undercurrent and the Equatorial Jet.

Transequatorial sections are chosen, as far as possible, in such a way that at least one section is included in each month in the three within the longitudinal limits of west 65° E, 65-85° E and east of 85° E respectively. On the whole, 31 vertical sections are prepared, out of which 11 sections are selected for the computation of zonal flux. The method of representation of the flux is novel that it displays the flux on a temperature-salinity diagram. Characteristic classes are chosen that are difined by thermosteric anomaly and salinity.

Unlike in the other major oceans, the Equatorial Undercurrent appears only seasonally in the Indian Ocean because of the reversal of the atmospheric circulation over the North Indian Ocean. It is present all along the width of the Indian Ocean with the normal characteristic features of the undercurrent, during February to April. But the commencement of the Undercurrent takes place in January in the western region, sometimess even in December. Further, it is noticed that in the beginning it is located slightly north of the equator due to upwind shift of the northerlies prevailing in the western region. The Undercurrent is also found to be initially develped in the western region and extends to the east and shifts south to the equator with time. Before the termination of the Undercurrent it is found to shift southward due to the wind shift. Also it is found that the Equatorial undercurrent in the Indian Ocean is absent from late June to early December.

Flux distribution during February, March and May in the western Indian Ocean presents slightly higher values in March. In general, the transport increases from the western to the central Indian during the latter period of northeast monsoon while it remains almost unchanged in the eastern region. The strong surface easterly flux present during the two transition periods denotes the Equatorial Jet and is symmetrical about the equator within 3° N and 3° S.

A limitation of the present study is that the data used for various sections do not pertain to the same year. With regards to the zonal flux estimation, it is not very correct to compute the same at and near the equator as it leads to uncertainty, the coriolis parameter which comes in the denominator being zero. To avoid this problem for computation of the zonal flux, the curent was computed at no two stations across the equator.

## M.S.53. SOSAMMA CHERIYAN–Glycogen Degrading Enzymes and their regulation in Benthic Animals and Estuarine Fish–1985–Dr. George Philip

The major control of glycogen degradation at the enzyme level is by glocogen phosphorylase in animals. To study the regulation of glycogen degradation in different aquatic animals, form different species were selected. They are *Etroplus suratensis*, a brackish water fish, *Metapenaeus dobsoni* an estuarine cum marine prawn and two bivalves *Sunetta scripta* (marine) and *Villorita cyprenoides* (estuarine). Among them *M. dobsoni* occupies the lowest evolutionary status and the bivalves are in between the fish and *M. dobsoni.*

Phosphorylase activity per gram tissue were found specific activity in the original extract were found to vary in the different animal tissue extracts in a definite manner consistent with the energy requirement of the tissues. The stability of the enzymes (measured by activity loss) in the extracts and at different stages of purification were found to correlate well with the evolutionary status of the animal. ie, higher the animal's status, the more stable the enzyme.

Phosphorylase was purified either completely or partially from the muscle of each of these species and the kinetic properties were studied. The presence of phosphorylase phosphatase and phosphorylase kinase were also tested in all these animals and also their action on crystalline rabbit muscle phosphorylase. From these it was found that both phosphorylase kinase and phosphatase were present in these animals like the other animals and hence the interconversion reaction plays an important role in the regulation of glycogen degradation in these animals also. Only the *M. dobsoni* muscle was found to have a latent form of phosphorylase phosphatase.

The specific activity and activity per gram of phosphorylase in the muscles of the different animals were different, the lowest being found for the bivalves. Activity ratios (activity in the presence of 1 mM AMP to that in its absence) were 0.23 and 0.3 for *Sunetta* and *Villorita* respectively.

Ammonium sulphate and sodium sulphate activated the *Sunetta, Villorita* and *Entroplus* phosphorylases. Heavy metals inhibit all the enzymes. Sodium chloride and potassium chloride had no activating or inhibiting effect. It was also found that except for *Etroplus* phosphorylase the other three phosphorylases were highly unstable, *N. dobsoni* being the least stable.

The kinetic analyses gave data consistent with rapid equilibrium mechanism for all phosphorylases studied. In the case of glycogen/glucose-1-P kinetics, except *Etroplus* phosphorylase the other three phosphorylases showed positive heterotropic cooperativity between the two substrate sites whereas *Etroplus* phosphorylase showed negative heterotropic cooperativity. Quantitatively the three phosphorylases were again different. Kinetics with the activator AMP was different for different species. *Villorita* and *M. dobsoni* phosphorylases showed negative homotropic cooperativity between AMP sites, *Etroplus* phosphorylase showed negative heterotropic cooperativity between glucose-1-P and AMP sites and *Sunetta* phosphorlase showed positive heterotropic cooperativity between them.

The metabolites ATP, glucose-6-P and glucose inhibited all the four enzymes though the pattern of inhibition was different. For *Sunetta*, *Villorita* and *Etroplus* these metabolites *a*, in the absence of AMP, mixed typeof inhibition was observed. In the presence of AMP, for *M. dobsoni* phosphorylase *a* glucose-6-P induced negative homotropic cooperativity between glucose-1-P sites. Another difference observed was that while glucose was the most potent inhibitor (among the three metabolites mentioned) for the fish phosphorylase, glucose-6-P was found to be the most potent inhibitor for the invertebrate phosphorylases.

The properties of the four animal phosphorylases were compared with respect to each other and with other well-studied animal muscle phosphorylases. Thus the interconversion between the *a* and *b* forms is a general mechanism of regulation of glycogen degradation in these animals also. Moreover the allosteric regulation by the metabolites glucose, glucose-6-P and ATP and activator AMP is also involved in the control of degradation of glycogen. Comparison of the properties of the phosphorylases reveals that the properties of the phosphorylases reveals that the properties of the enzyme and its control can be explained by two factors *viz.* the evolutionary status of the animals and the energy requirement of the muscle.

### M.S.54. SASIDHARAN PILLAI, N.K.–Studies on the copepod fish parasites of Kerala coast–1985–Dr. M. Shahul Hameed

The thesis presents mainly the systematics of the copepod fish parasites of Kerala Coast. Fish parasites for this study were collected from different Fish landing centres of the Kerala coast. Majority of the species were recorded from Cochin region. About 70 species of the parasites were recorded from the Cochin region. About 70 species of the parasites were recoreded from the marine fishes, both elasmobranchs and teleosts fishes. The fish parasites so far collected include the suborders, Cyclopoida, Caligoida, and Lernaeopodia. Identification keys of the collected specimens were prepared and the species with insufficient description were redescribed in detail. Female specimens were taken for the purpose of identification.

The specimens that were identified as new species were studied in detail and ascertained their identity beyond doubt. New host records and distribution records were also noticed and described.

The present study also includes the host-parasite relationship exhibited by this group of parasites. During the course of the systematic studies interesting observations regarding the relationship of copepod parasites with host fishes were noticed.

Besides, the frequency of occurence and distribution was also included. The present study also includes the host specificity nature exhibited by the members of this group of parasites.

### M.S.55 MERCY THOMAS–Studies on portunid crabs–1985–Dr. R. Damodaran

Reproduction in five species (*Portunus pelaqicus, P. sanquinolentus, Scylla serrata, S. serrata serrata) (Podopthalmus vigil* and *Thalamita crenata)* or crabs presently studied covers length frequency distribution, size at first maturity, sex ratio, fecundity and annual reproductive cycle. Length frequency distribution in samples collected from the commercial catches and from the field revealed that the matured froms and older groups contributed to the fishery than immature group forms.

There was a good linear relationship between fecundity and carapace of crabs presently studied. *P. pelaqicus, S. serrata* and *T. crenata* were found to breed for an extended period but breeding was not continuous year round. *P. sanquinolentus* and *S. serrata serrata* were found to be continuous breeders.

Length-weight relationship studied in five species and one subspecies of these commercially important crabs showed that cube law is obeyed. Males and females in two species and one subspecies namely *S. serrata, T. crenata* and *S. serrata serrata* did not show significant variations but in other three species namely *P. pelaqicus, P. sanquinolentus* and *P. vigil* the difference was significant.

In the larval development studied presently in *T. crenata* by rearing the larvae, 3 zoeal stages and a megalopa were noticed under laboratory condition. The shortest duration of all zoeal development was found to be 15 days.

Mortality rate was heavy in the I zoeal stage. The day of each moult and mean intermoult duration increased as the salinity decreased.

Proximate composition was also studied in *T.crenata.* Though the total meat content increased progressively in higher size groups, the percentage of meat was more in lowest size group crabs (10–20 mm). In males the percentage of meat varied from 26.3 to 20.7%. In females the range was 23.3–16.4%.

Proximate composition varied in relation to size and sex and from the nutritive point of view, small animals which have high protein and less fat were found to be advantageous.

### M.S.56. ANVAR BATCHA, S.M.–Studies on bottom fauna of north Vembanad lake–1985–Dr. R. Damodaran

Investigation was carried out to study the ecology and abundance of bottom fauna from Cochin barmouth to Vaikam Jetty area in 18 stations, in the northern part of the Vembanad lake.

The studies on both surface and bottom water temperatures had indicated a biomodel type of oscillation, to a greater extent controlled by the south west and north east monsoons.

Among the hydrographical parameters studied, salinity was found to be the most fluctuating environmental factor.

Regarding dissolved oxygen content of the north Vembanad lake, unlike temperature and salinity, in general high values were associated with south west monsoon period.

As far as the sediment is concerned, sand is the dominating component in all the stations with an admixture of silt and clay.

The organic matter content showed seasonal variations, along with the physical nature of the sediments.

The bottom fauna was studied in detail with its distribution and composition, numerical abundance, species diversity, biomass and its relationship to hydrography and sediment.

For the region as a whole *P. polybranchiata* was found to be the single species recorded in all the stations in large numbers.

The crustacea was mainly represented by amphipods, isopods, tenaids and decapods.

The major forms of molluscan fauna represented were *Modiolus undulatus* near the barmouth region, *Nuculana mauritiana* in the mid-reaches and *Villorita cyprinoides* var *cochinensis* in the upper reaches of the north Vembanad lake.

The other groups were represented by Coelenterates, nematodes, nemertines and Pisces.

A distinct pattern of distribution of botton fauna was observed during the present investigation.

The maximum number of bottom fauna were observed in the pre-monsoon season followed by the Post-monsoon season.

Regarding biomass values, the standing crop of the bottom fauna was high in the barmouth region.

## M.S.57. CHANDRASEKARAN, M.-Studies on the Microbial spoilage of Penaeus Indicus'-1985-Dr. D. Chandramohan and Dr. Lakshmana Perumal Samy, P.

The present investigation was carried out mainly to build up the knowledge on the role of commensal bacteria present on the prawns during storage at various temperatures. The main objectives of the study includes evaluation of sopilage in raw untreated penaeid prawns Penaeus indicus, immediately after catch, at room temperature and at 4°C and −18°C, changes in the proximate composition during spoilage, isolation and characterization of bacterial flora and their growth kinetics.

The thesis contains five major chapters. First chapter forms the Introduction part covering preface, review of relevant literature and research approach. Second chapter presents in detail the Materials and Methods employed in the present investigation - Third chapter gives an exhaustive account of the results of the various studies conducted in the present investigation. Fourth chapter forms the Discussion part and fifth chapter presents the Summary. Apart from these, references cited and list of publications are also included.

In the preface section, the relevance of undertaking the present investigation, in the lights of commercial importance of *Penaeus indicus* in the Seafood Industry and the need for a study to find out the role of commensal bacteria in spoilage is discussed. The Review section presents the quantum of scientific knowledge accumulated in the past on spoilage studies carried out with regard to microbiology of *Penaeus indicus* in and out of India. The research approach section highlights the main objectives of the present study which includes (1) evaluation of spoilage of prawns by organoleptic assessment, estimation of Total Heterotrophic Bacterial Population (THB), trimethylamine (TMA), Ammonia and pH, (2) changes in the proximate components such as protein, lipid, carbohydrates, ash and moisture content, (3) generic composition of THB, (4) hydrolytic enzyme producing heterotrophs, (5) determination of spoilage potential of bacteria, (6) growth kinetics and (7) mixed population studies.

In the second chapter 'Material and Methods', details regarding the sample; collection, transportation and treatment of sample; procedures for organoleptic assessment; THB; TMA; ammonia; pH; isolation; identification; testing of hydrolytic enzyme production; determination of spoilage potential in flesh media and Trimethylamine oxide (TMAO) reduction to Trimethylamine (TMA) are presented. Also, methods by which, effect of temperature, pH and sodium chloride concentration on growth and survival of selected strains; generation time and behaviour of mixed cultures in flesh borth studied are described in detail.

The third chapter which forms the 'Results' gives an account of the major findings of the present investigation. *Penaeus indicus* was used in the present study in four types namely 'whole', 'Headless', 'Peeled and undeveined' (PUD) and 'Peeled and deveined' (PD). They were stored as raw unprocessed prawns at 28 ± 2°C, 4°C and −18°C. Organoleptic assessment suggested rapid spoilage of all the four types of prawns by 8 hours at 28 ± 2°C, by 10 days at 4°C and 100 days at −18°C. THB was found to be increased to a maximum level exceeding a log of $10^9$ at 28 ± 2°C and 4°C and a log of $10^8$ at −18°C, in all the four types of samples. TMA was found to be increased significantly from O u g/g to around 20.87 ug/g at 28±2°C, 20.59 ug/g at 4°C and 16.66 ug/g at −18°C in all the samples. Ammonia level also increased from O ug/g to around 298.4 ug/g at 28 ± 2°C, 576.8 ug/g at 4°C and 280.3 ug/g at −18°C for the samples. The level of pH, which was initially 6, was found to be increased to around pH 7.55 at 28 ± 2°C, pH 8.55 at 4°C and pH 8.5 at −18°C for the samples.

Protein, lipid, carbohydrate and ash contents showed significant reduction. Also a significant increase of moisture from their initial level in the samples at all the three storage temperatures, was recorded.

Species of *Pseudomonas, Vibrio, Acinetobacter, Micrococcus, Bacillus, Corynebacterium* and members of Enterobacteriaceae were found to constitute the bacterial flora in the fresh prawns. During storage at 28 ± 2°C, *Vibrio* sp showed dominance over *Pseudomonas, Acinetobacter* and others in all the samples. At 4°C *Pseudomonas* showedd dominance followed by *Vibrio* and *Acinetobacter*. At −18°C *Pseudomonas, Acinetobacter* and *Micrococcus* showed dominance at various occasions followed by *Vibrio* and *Bacillus*. Among the various hydrolytic enzyme producers proteolytic forms were dominant followed by lipolytic, amylolytic and ureolytic forms at all the three storage temperatures. Among the 219 isolates used for the determination of potential spoilers in flesh media about 63% of the isolates were found to be potential spoilers. Species of *Vibrio, Pseudomonas* and *Acinetobacter* formed the major flora. Among 178 isolates tested for TMAO - TMA reduction, 92.1% of the isolates were TMAO reducers. Species of *Vibrio, Pseudomonas* and *Acinetobacter* were found to be the major TMAO reducers.

Eight isolates representing species of *Pseudomonas, Vibrio* and *Acinetobacter* were studied for their growth kinetics. They were tested in flesh broth and Zopell's broth. When tested for the effect of temperature, pH and NaCl conc. on growth and survival, it was observed that they grow well at temperatures between 15°C and 45°C, pH 6 and pH 10 and at 1 - 6% NaCl conc. irrespective of the culture media. They survived well at 45°C and 5°C than at −15°C and 60°C and at pH 6 - pH 8.6 and at 0 - 6% NaCl conc. However their percentage of survival decreased with increase of time. When tested for the effect of temperature, pH and NaCl conc. Combined with each other at various levels on the growth of bacteria, it was found that all the isolates could grow at pH 6 – 10 at alll the temperatures (5°, 15°, 30° and 45°C) and at moderate sodium chloride conc. However incubation at 30°C with 1% and 3% NaCl conc. and pH 6 and pH-8 in the media was observed to favour the growth of almost all the isolates than any other combination. It was observed that generation time of the isolates was not same in both the media viz. flesh broth and ZoBell's, tested. They varied according to media for each strain.

When strains of different species were mixed together at various inoculum size and grown in flesh broth the recovery of individual strains were observed to be influenced by the type of species than the inoculum size. When *Pseudomonas* sp and *Vibrio* sp, isolated from prawns stored at 28+2°C were mixed, *Vibrio* sp was recovered in higher percentage. Similarly, when *Pseudomonas* sp, *Vibrio* sp. and *Acinetobacter* sp, isolated from prawns stored at 4°C, were mixed at various proportion, on most of the occasions *Pseudomonas* sp out numbered others.

The fourth chapter includes the discussion of the results obtained in the present investigation drawing an insight on the facts and features of various factors governing spoilage and related studies undertaken.

Fifth chapter summarises the whole thesis work in a nutshell.

## M.S.58. CHINNAMMA GEORGE–Biochemical changes associated with processing of shellfishes and flavour constituents of body meat and claw meat of crab–1985–Dr. K. Gopakumar.

Industrial processing of crabs, mussels and clams although taken widely in India has not shown rapid strides as expected in terms of quantity inspite of heavy demands from overseas markets. This is largely due to the lack of precise information on the resources and absence of technical data on the amenability to processing of the different varieties available. The high labour costs involved in harvesting and separating the muscle from the shell and the subsequent removal of sand from the meat (clam) also hinder their industrial processing economically. This investigation is carried out with a view to understanding of many of such aspects with direct application to the seafood industry.

From the size-weight measurements of crab *(Scylla serrata)* the whole weight and meat weight can be computed if length alone is known. Crab body meat and claw meat differ markedly in organoleptic qualities. The difference is established in terms of bio-chemical characteristics. The seasonal influence on bio-chemical parameters of crab muscle is another piece of study.

From the results it is concluded that season has profound influence on chemical composition and it is known to affect the qualitative and quantitative nature of the microflora associated with fish and fishery products. Changes in quality of crab muscle stored at different temperatures viz. 37°C, 25-28°C, 6.5-7.5°C and 0°C are studied. High temperatures enhance rapid spoilage. In live crabs the flesh is held to the shell by a membrane making it difficult to remove the meat. If it is stored in ice for 18-24 hours, the membrance breaks down and the flesh can be easily taken out as flakes. The high rate of spoilage in shellfishes may be attributed to the high percentage of free amino acids (in crab muscle about 50% of the non-protein nitrogen fraction is amino nitrogen). There is a slow but gradual decrease in the sarcoplasmic protein fraction in crab muscle frozen and stored at −23°C, but the extractability of myofibrillar protein diminished at a faster rate compared to other protein fractions. The adenosine triphosphatase activity of actomyosin dropped from 24.3 to 0.098 ug/Pi/mg protein/minute during a period of 48 weaks. The development of tough texture during frozen storage of fishery products can be correlated to the protein denaturation leading to the loss of water holding capacity of the muscle. The drip loss increased with frozen storage life and the frozen storage quality is found to have a direct bearing on the pre-freezing ice storage life.

The use of harmless chemical glazes in retarding the deleterious changes due to freezing and storage is studied and found that a mixture of ascorbic-citric acids (1% solution in the ratio 1:4) is distinctly advantageous in prolonging the shelf-life of frozen crab muscle. The optimum cooking time for crabs in boiling water or steam without pressure is 15 minutes. Four series of studies were conducted under varying conditions of raw materials to compare the frozen storage characteristics. The details of the study is given below:

1. cooked and iced *vs* iced and cooked
2. raw *vs* cooked shellon
3. raw *vs* cooked meat alone and
4. raw *vs* cooked claw with shellon

Canning conditions are standardised to prepare good quality canned product. The nutrients lost in brine is also estimated.

The relation between height and length and height and meat weight are studied for wild and cultured variety of mussels (*Perna viridis*). Proximate chemical composition, protein fractions and free amino acid patterns are reported. The relation between age and chemical constituents are also studied. The results prove the existence of highly significant correlation between height and alpha amino nitrogen, glycogen and ribose. Biochemical, bacteriological and organoleptic changes in mussels stored in ice proved that in 10 days time the material reached the stage of Fair to Poor (score 4 on hedonic scale) with slight loss of characteristic flavour and yellowish discolouration.

Under frozen storage the changes observed in mussel meat are:

(1) colour changed from white to dull white and to brown as spoilage increased.

(2) the firmness and elasticity of the material is replaced by sponginess accompanied by fluid loss.

(3) loss of characteristic sweet flavour.

Standard plate count during ice storage showed steady increase. But during freezing and storage after 44 weeks at −23°C, the viable count came down by 99%. Reduction in pathogenic organisms like *E. coli* and *F. streptococci* is observed. *E. coli* is completely destroyed towards the end. Studies on cooked frozen mussel meat revealed that precooked and iced lot had more shelf-life (38 weeks) than pre-iced and cooked samples (16 weeks). Discolouration and hardening of texture increased with progressive pre-process ice storage.

Canning procedure was standardised for mussel meat and nutrients lost in brine was worked out.

The length-height relationship was worked out for clams (*Villorita* sp.). The correlation coefficient was highly significant. The studies on proximate composition of clam meat revealed wide variation during different seasons of the year especially in protein, amino acids, glycogen, ribose and fat contents. Retention of sand in the muscle was occurred even if care was taken to remove the gut portion. Regarding food value, clam meat is slightly inferior to crab or mussel meat. Protein fractions isolated from clam muscle revealed more percentage of sarcoplasmic proteins and lesser quantity of myofibrillar protein than crab and mussel.

The free amino acid pattern of clam muscle is also reported. Live clams stored in ice had a self-life of 9 days. A good correlation was obtained between quality determined organoleptically and the amounts of water soluble nitrogen, free amino nitrogen, glycogen and inorganic phosphorous retained in the muscle. During frozen storage the soluble protein was dropped from 63.0 to 55.0% in uniced samples and from 59.4 to 47.3% in samples iced for 8 days. The loss in solubility of muscle protein was related to the change in texture, water holding capacity of the muscle and the loss of juiciness. The uniced samples had a shelf-life of 35 weeks and that of 8 days iced sample had only 4 weeks.

The total plate count decreased during frozen storage. The pathogenic organisms like *E. coli* and *F. streptococci* also showed the same trend.

The analytical date of the canned products prepared from clams stored under ice up to 13 days is presented. Due to high concentration of glycogen in mussel and clam black precipitate was formed during colour development for ribose estimation according to standard Mejbaum's method. Remedial steps were worked out to prevent precipitation with 95±5% accuracy.

The results of the investigations prove that a number of parameters as reported in this work have to be consideredd and evaluated both at harvesting and subsequent post-harvesting and processing of these valuable food commodity if it is to be an economically viable proposition industrially.

## M.S.59. MADHUSOODANAN, P.–Water characteristics and Current structure of the Intermediate waters in the Arabian Sea–1986–Dr. G.S. Sharma.

Circulation and water characteristics of the intermediate waters in the Arabina Sea are influenced by the high saline waters (Red Sea and Persian Gulf) from the north and low saline waters from the south of equator. The interaction of these waters which greately differ in characteristics is less understood compared to that at the upper layers. Hence, an attempt is made in the present investigation to study the water characteristics and current structure of the intermediate waters in the Arabian Sea. The study is carried out by presenting the topography of different isanosteric surfaces of the intermediate waters and the distribution of acceleration potential and salinity on these surfaces, besides presenting the vertical sections along different latitudes and longitudes in the Arabian Sea. The water characteristics are also studied by working out the different representative areas in the Arabian Sea. An attempt is also made to present the potential vorticity between different steric levels to understand the circulation and mixing processes. Data collected during the International Indian Ocean Expedition and subsequently in the Arabina Sea are used for the study. The area covered north of the equator upto the border of Asian Continent, excluding the Red Sea and Persian Gulf is considered.

Constant potential thermosteric anomaly surfaces of 100, 80, 60 and 40-cl/t, covering the intermediate waters are chosen for the study. The topography, acceleration potential and salinity maps are prepared for the above surfaces. The geostrophic flow along the isanosteric surfaces was deduced from the gradient of acceleration potential using 2,000 db as the reference pressure. Five zonal and two meridional sections of potential temperature and salinity and 10 scatter diagrams of potential temperature against salinity are presented. Potential vorticity is computed using a novel method, introduced by McDowell et al. (1982), from the hydrographic measurements of the potential density alone.

The distribution of properties on potential thermosteric anomaly surfaces showed zonal flow near the equator, meridional flow along the Somali Coast and off the southwest coast of India on the upper three surfaces, whereas meridional flow predominates on the lower surface. An important feature revealed on the distribution of acceleration potential is a westward flowing undercurrent near the equator between 45° and 75° called as Intermediate Equatorial Current. Another remarkable result is the presence of southward undercurrent along the Somali Coast. The striking feature on the topography as well as on the distribution of acceleration potential is the occurence of lows and highs indicating cyclonic and anticyclonic eddies. Some of these closed eddy type circulation are formed due to the manifestation of baroclinic instability prevailing in these areas as evident from the distribution of potential vorticity between different steric surfaces.

An interesting feature is the rapid decrease of salinity from the central Arabian Sea towards south and southeast on 100 and 80-cl/t surfaces suggests the horizontal advection of Red Sea Water. The influence of Pacific Ocean Water is observed in the western region of the equatorial section as a week salinity minimum. Horizontal mixing is predominant in the central western and eastern Arabian Sea whereas the prominance of vertical mixing is indicated in the southeastern and northern Arabian Sea. The advection of Red Sea Water, Persian Gulf Water and the northward flow of low saline water from south are evident from the distribution of properties on the isanosteric surfaces, vertical section with the waters of the others except in the south, probably, a consequence of closed boundary on its northen border. There is less renewal of water other than horizontal and vertical mixing confined to the same region unlike in the other regions of the world oceans at similar latitudes. To identify the step structure and Western and Eastern Boundary currents which are conspicuous characteristics of the intermediate waters, further studies at closer network with moored buoy stations for current measurements and STD that provides continuous profiles to study the finer structure are required.

## M.S.60. REVIKALA, S.–Some aspects of phytoplankton blooms in relation to pelagic fishes–1986–Dr. V.D. Ramamurthy.

A total number of 25 phytoplankton blooms were studied. Characterization of the phytoplankton blooms includes observing the cell counts (cells/ml) from the day of its appearance till its disappearance.

Out of the total blooms, 17 were caused by diatoms, 5 by dinoflagellates and 3 by blue green algae. In the region of diatom and blue green alga blooms lot of pelagic fishes were seen. Fishes avoided the dinoflagellate blooms but no mortality, off odour or irritation were noticed. The gut contents of the pelagic fishes found in the bloomed regions revealed that the bloomed organisms were very common in the guts. An year round study of the gut content analysis of the pelagic fishes from September 1983 to August 1984 were done in order to see whether the bloomed organisms are included or not in the general feed.

The diatoms like *Pv zidicule minuta* Grunow, *Cyclotella* spp., *Coscinodiscus* spp., *Rhizosolenia* spp., *Biddulphia* spp. and *Fragilaria oceanica* Cleve were seen more in the guts of some the pelagicc fishes during, before and after the bloom period.

## M.S.61. SOBHA PRATAP RAO SHERE–Studies on sporulation and propagation on selected Agarophytes–1986–Dr. P.V. Ramachandran Nair.

Studies on sporulation of four commercially important agarophytes *Gelidiella acerosa, Gracilaria corticata, G. edulis* and *Hypnea musciformis* growing in the civinity of Mandapam coast were carried out from October 1981 to September 1983. During the study, fruiting behaviour in the natural population of these species was also investigated.

Maximum output of tetraspores and carpospores were observed mostly on the first day of the experiment in the four red algae studied. The tetrapore output decreased from second day onwards and rhythmic liberation of carpospores with peak shedding of spores at intervals of different days was also observed.

In the experiments conducted in the laboratory to study the effect of environmental factors, spore output declined with increase in the duration of exposure of fruiting thalli in shade and maximum number of spores were liberated from the plants mostly under submerged condition. The spore output varied in different salinities tested.

The germination of tetraspores in *Gelidiella acerosa* and tetraspores and carpospores in *Gracilaria corticata, G. edulis* and *Hypnea musciformis* occurred throughout the year in the laboratory conditions. But under selected environmental factors in the laboratory, maximum number of dividing tetraspores in *Gelidiella acerosa* and tetraspores and carpospores in *Gracilaria corticata, G. edulis* and *Hypnea musciformis* occurred in submerged conditions, at salinities ranging from 20-40‰, light intensity from 500 to 3000 lux and temperature 25 to 30°C.

Mode of germination observed in *gelidiella acerosa* was that o 'Gelidium type' and that observed in *Gracilaria corticata, G. edulis* and *Hypnea musciformis* was that of *'Dumontia type'*.

## M.S.62. CECILY, P.J.–Materials for Fish net, their properties, selection and preservation–1986–Dr. C.T. Samuel.

While determining the linear density of netting materials it was found that among the vegetable fibres, Italian hemp is heavier than other materials of the same thickness with sunhemp, flax, sisal, manila and coir following in the order, coir being the lightest among the materials tested. In the case of synthetic twines PE monofilament braided twine was found to be the heaviest.

Evaluations of physical properties of vegetable and synthetic twines used for indigenous nets revealed the need for uniform twists and stability of twines by maintaining the correct ratios for inner and outer twists.

Comparative studies of trawl nets made of different materials including PE monofilament and PE flat tape twines proved the utility and cheapness of these materials for bottom trawls.

Regarding the strength property of netting twines, a comparative study showed that among vegetable fibres, Italian hemp is more than twine as strong as sunhemp. The strength decreased in the order of flax, manila, sun-hemp and sisal. Coir twines exhibited poor strength compared to other materials.

Regarding the comparative breaking stretch values of different vegetable fibre twines, it was evident that the extensibility of sunhemp was lower than those of Italian hemp and flax. Sisal and manila twines exhibited almost the same breaking stretch, while cotton and coir showed greater elongation as compared to the vegetables fibre twines. In all the vegetable fibres tested, the breaking stretches were found to be more in wet condition that in dry condition. In the case of synthetic twines, the correlation between diameter and dry and wet breaking stretch was found to be non-significant in all types of twines tested. One possible explanation is that the stretches of twines are independent of thickness.

It was found that by mixing of yarns it is possible to produce a new yarn which has got a different property from that of the component yarns.

Monofilaments of polyamide, polypropylene and polyethylene were mixed and the combination twines proved to be a better product and it is expected that the mixed monofilaments can be used for lines and ropes.

## M.S.63. SILAS EBENEZAR, A–Studies on the Ecology and productivity of Saline lagoon–1986–Dr. P. Parameswaran Pillai.

A shallow lagoon at Mandapam Peninsula known as Pillaimadam Lagoon (09°17'N to 09°17'48' 'N and 79°5'E to 79°8'24' 'E), having an area of *ca* 300 ha and situated along the Palk Bay Coast, was selected for the present study.

1. The pertinent literature on the subject is reviewed and the lacuna in our knowledge on the ecology and productivity of the coastal direlict saline lagoons of India presented.
2. The study was undertaken from July-1982 to June-1984. Five stations were selected for regular ecological and primary productivity sampling in the Pillaimadam Lagoon and one in the Palk Bay.
3. Meteorological data pertaining to monthly mean minimum and maximum termperature, relative humidity and wind velocity of this region have been collected, analysed and presented.
4. Information on the air temperature, water temperature, water depth, dissolved oxygen, salinity, pH, soluble reactive phosphate, nitrate, nitrite, ammonia and hydrogen sulphide of water was collected every week during the period of observation and the results obtained have been analysed and presented.
5. Sediment samples were analysed fortnightly for estimating the organic carbon, total phosphorous, Kjeldhal nitrogen and total sulphide contents. The results are presented and discussed.

6. The rate of gross primary production and net primary production were studied at fortnightly intervals. The results are analysed and discussed.
7. The correlation between ecological aspects and primary productivity parameters for each station is calculated and the significance of correlations highlighted.
8. The quantitative and qualitative distribution of zooplankton during the period November-1983 to March-1984 in the lagoon has been worked out.
9. The macrobenthos of the lagoon are analysed qualitatively and quantitatively and the results presented and discussed.
10. Studies on the grain-size distribution were undertaken for the pre-monsoon, monsoon and post-monsoon period of 1982 and 1983, and the results of analyses were discussed in relation to sediment chemistry.
11. Studies on the vertical profile of the sediment were undertaken at bimonthly intervals and analysed for organic carbon, total phosphorous and Kjeldhal nitrogen contents. Results of the analyses are presented and discussed.
12. Coastal flora of lagoon are collected and the common species identified.
13. In order to understand the diurnal variation of hydrological parameters in the environment, diurnal study was undertaken during the pre-monsoon, monsoon and post-monsoon seasons of1983-'84, covering one new moon and one full moon phase in each season. Four stations were selected for this study and observations were made on the distribution of dissolved oxygen, surface and bottom salinity, soluble reactive phosphate, nitrate, nitrite and ammonia concentrations at every three hours starting from 0900 h of the day of sampling to 0600 h of the successive day.
14. To delineate the effect of fertilization on the primary productivity of the lagoon, enrichment experiments were conducted from February-1984 to May-1984. Four sets of enrichment experiments, under *in situ* and *in vitro* conditions were performd. Fertilizers such as 17:17:17 N:P:K-Complex, organic mixture, urea, superphosphate, potash, potassium nitrate, sodium phosphate and d-glucose were used under different concentrations and applications to assess their effect on primary production.
15 After enrichment with nutrients, the water was analysed for dissolved oxygen, salinity, pH, soluble reactive phosphate, nitrate, ammonia, gross primary production and net primary production and the results are discussed.
16. The suitability of the lagoon for mariculture practice is assessed based on the results obtained from the ecological, productivity and nutrient enrichment studies.
17. The data on the above aspects, wherever necessary are presented in tabular and graphical forms for effective understanding.
18. A detailed literature on the subject matter of the thesis is presented at the end.

## M.S.64. SUSEELAN, C.-Studies on the deep-sea prawns off south west coast of India-Dr. E.G.Silas.

A detailed study of the deep-sea prawns of the continental shelf and upper continental slope (100-450 m depth) along the southwest coast of India between Cape Comorin and Bhatkal (Lat. 7°N-14°N) has been carried out based on the catches of exploratory fishing conducted by the Government of India exploratory fishing vessels during 1965 to '79. A total of 22 species of prawns belonging to thirteen genera representing six families, namely, Solenoceridae, Aristeidae, Penaeidae, Oplophoridae, Pasiphaeidae and Pandalidae collected from the deep-sea catches have been described. Keys for the identification of the species have been provided. *Plesionika williamsi* Forest, one of the large size pandalids reported to have commercial significance in tropical west Africa, is recorded from the Indian Ocean for the first time. Three species, namely *P. ensis* A.M. Edw., *P. sindoi* Rathbun and *Heterocarpus sibogae* de Man are reported as new distributional records to the Arabian Sea. The identity of *Solenocera melantho* de Man and *Aristeus semidentatus* Bate previously reported from the Indian waters has been critically examined and changed to *Solenocera halli* Starobogatov and *Aristeus alcocki* Ramadan respectively.

The occurrence and quantitative distribution of deep-sea prawns in different latitude zones have been studied depthwise and productive areas mapped out based on the catches of 1187 hauls of bottom trawl. It has been found that the area lying between 100 and 200 m depth on the continental shelf of this coast is not significantly productive for prawns to support any commercial fishery. Relatively high concentration of prawns has been noticed in the 'Quilon Bank' at 301-375 m depth and in slightly deeper areas off Ponnani on the upper continental slope. In the northern latitude zones the maximum density is observed between 201-300 m depth along the Malabar coast. Seasonal distribution of catch-per-effort returns from Quilon Bank indicates peak abundance of the resource during December to February.

The deep-sea prawn catches are multispecies in character, the bulk of the fishery being constituted by *Heterocarpus woodmasoni* (38.5%), *H. gibbosus* (6.4%), *Parapandalus spinipes* (18.6%), *A. alcocki* (9.0%) and *Penaeopsis jerryi* (9.9%). A comparison of the species assemblage in different latitude zones shows that the fishery is chiefly supported by pandalid prawns Cape Comorin and Cochin and by penaeid and aristeid prawns between Cochin and Bhatkal. Depthwise comparison of catch composition indicates predominance of *Metapenaeopsis coniger* at 100-150 m, *P. jerryi* at 151-200 m, *P. jerryi* and *P. spinipes* at 201-300 m, *H. woodmasoni* at 301-400 m and *A. alcocki* at 401-450 m depth.

The spatial distribution and abundance, size composition, sex ratios, maturity, facundity, breeding, food and feeding habits and length-weight relationship of major species have been dealt with. None of the species indicate sex reversal as exhibited by many species of deep-sea prawns of the arctic and temperate waters.

## M.S.65. SANTOSH, M.-Petrochemistry, Related Mineralization and Genesis of the Ambalavayal Granite and Associated Pegmatites, Wynad District, Kerala-1988-Dr. Nair, N.G.K.

The Kerala region which forms a significant segment of the south-western Indian shield, dominantly comprises charnockites, khondalites and migmatitic gneisses of Precambrian age. Recent investigations have revealed the occurrence of a number of younger granite and syenite plutons in this region, spatially related to regional fault-lineaments. The granite of Ambalavayal in Wynad district of northern Kerala is a typical member of this suite of intrusives. A comprehensive study in terms of geology, petrology, goechemistry and petrogenesis of the

Ambalavayal granite, basement gneisses, associated pegmatites, quartz veins and related mineralization that together cover an area of about 90 sq km in Wynad district of northern Kerala.

The dominant rock types of northern Kerala are charnockites and migmatitic gneisses. The granite plūton of Ambalavayal is emplaced within Precambrian biotite gneisses and is spatially related to the intersection of two regional fault-lineaments, namely, the Moyer and Calicut lineaments.

The granite shows a hypidiomorphic granular texture with quartz and alkali feldspar as the major minerals. Alkali feldspars show microcline cross-hatching. Greenish pleochroic hornblende is the major mafic mineral. Accessories include biotite, riebeckite, zircon, apatite, sphene, epidote, monazine and calcite. The Q-A-P proportions calculated from detailed modal analyses data assign the granite to be "alkali feldspar granite"—type. The molybdenite flakes are seen as leafy aggregates adhering to the silicate minerals and more commonly show preferential distribution along grain boundaries of quartz and feldspar.

Chemical analyses of molybdenite fractions yield an average Mo contents of 58.4%, with traces of Fe, Ni, Ti, Cu and Pb. X-ray analyses of molybdenite fractions indicate characteristic 2 0 values and corresponding d-spacings and hkl values of the hexagonal 2 layer-$2H_1$ polytype.

Detailed fluid inclusion studies of quartz from the granite, pegmatites and quartz veins have been carried out. A number of doubly polished plates of quartz were prepared and fluid inclusion potrography has been documented. Heating studies were done using a Leitz-1350 heating stage and freezing runs using a CHAIXMECA freezing stage. Fluid inclusion petrography shows that there is a positive correlation between the abundance of carbonic inclusions and the hornblende/biotite ratio in the granite.

Major and trace element geochemistry of 24 representative samples of the biotite-gneisses, 3 samples of mafic-rich enclaves ('restites') and 2 samples of fuchsite quartzites are also presented.

The petrogenesis of the granite and its tectonic implications are brought out in detail. Based on Log Rb Vs. Log Sr plots, it is inferred that the depth of generation of the granite magma was about 20-30 Km. The generation of the granite magma is correlatedd with the pre-lift tectonics of the Indian continent. Crustal warping and distension lead to mantle degassing.

## M.S.66. SANTHADEVI, M.R.–Studies on energy exchange in the Arabian sea–1986–Dr. G.S. Sharma

An attempt is made to identify the major characteristics of the ocean atmosphere system in the Arabian Sea in order to explore the complex role of interaction of ocean with atmosphere. Because of the interdependence between the ocean and the atmosphere every process taking place in the atmosphere has its reflections on the ocean and vice versa.

The mean monthly fluxes of sensible heat, latent heat and momentum computed using the bulk aerodynamic formulae for each 2° latitude logitude grid for the Arabian Sea forms the basis of the present study. The computations offer a valuable means of finding the regions of maximum interaction and determining the local predominating process operating in the atmosphere and the ocean.

The distribution of the fluxes portray anomalous amplitude in energy exchange during the course of an year. The general trend of the sensible heat, latent heat and momentum transfer is related to the strengthening and weakening of the two monsoons.

It is interesting to note that the momentum transfer is invariably in phase with the sensible heat transfer. The momentum transfer is mostly associated with regions of convergence and divergence which are again related to heat sources and sinks. Sensible heat transfer is almost a gain throughout the year in the western region of the Arabian Sea agreeing well with the momentum transfer. The area off Somalia is highly divergent during southwest monsoon. Because of the strong horizontal gradient in sea surface temperature the sea has variable effect on the stability of the lower atmosphere and in its uptake of moisture. Thus in the western Arabian Sea several factors operate simultaneously and in many cases are dependent on each other.

Although high wind speed persists throughout the monsoon the latent heat becomes suppressed in the later part of the season by very low vapour pressure gradient between sea and air in response to the strong negative sea air temperature difference. Very low latent heat loss and comparatively high sensible heat gain and high momentum gain characterize the area as an energy sink.

There is a sharp increase of loss fluxes to a pronounced maximum in the eastern Arabian Sea during June. The large positive Sea air temperature difference cause large vapour pressure difference. These along with strong southwesterlies cause the observed maximum in the fluxes.

During northeast monsoon, in the northern Arabian Sea the sensible heat at momentum transfers are out of phase, whereas sensible heat transfer is in phase with latent heat transfer. The area is divergent and so the momentum transfer is from the atmosphere to the sea. However, the air temperature is still less so that the sensible heat and latent heat are transferred from the sea to the atmosphere.

There are cases when latent heat and momentum are in phase where the ocean loses latent heat at well as momentum but it gains sensible heat. Such a situation prevails in August along the eastern Arabian Sea. The southwesterlies are conergent in the eastern Arabian Sea resulting in loss of momentum to the sea.

As expected for the equatorial region, the annual variation of fluxes are comparatively modest except immediately adjacent to Somalia.

## M.S.67. ANILKUMAR–Studies on the Meteorological Aspects of Air Pollution Over Cochin–1986–Dr. D.V. Viswanathan

Pollutants that once enter into the earth's atmosphere become part of the atmosphere and hence their dispersion, dilution, direction of transportation etc. are governed by the meteorological conditions. The Thesis deals with the study of the atmospheric dispersion capacity, wind climatology, atmospheric stability, pollutant distribution by means of a model and the suggestions for a comprehensive planning for the industrially developing city, Cochin.

The definition, sources, types and effects of air pollution have been dealt with briefly. The influence of various meteorological parameters such as vector wind, temperature and its vertical structure and atmospheric stability in relation to pollutant dispersal have been studied. The importance of inversions, mixing heights, ventilation coefficients were brought out. The spatial variation of mixing heights studies for the first time on a microscale region, serves to delineate the regions of good and poor dispersal capacity. A study of wind direction fluctuation, $\sigma_\theta$ and its relation to stability and mixing heights were shown to be much useful. It was shown that there is a necessity to look into the method of computation $\sigma_\theta$ of The development of Gaussian Plume Model along with the application for multiple sources was presented. The pollutant chosen was sulphur dioxide and industrial sources alone were considered.

The percentage frequency of ocurrence of invérsions and isothermals are found to be low in all months during the year. The spatial variation of mixing heights revealed that a single mixing height cannot be taken as a representative for the whole city because of its wide spatial variations. The southern portions of the city have low mixing heights and monsoonal months showed lowest mixing heights. The study of ventilation co-efficients showed values less than the required optimum value 6000 $m^2/5$. However, the low values may be due to the consideration of surface wind alone instead of the vertically averaged wind.

Relatively more calm conditions and light winds during night and strong winds during day time were observed. During most of the year westerlies during day time and northeasterlies during night time are the dominant winds.

Unstable conditions with high values of $\sigma_\theta$ during day time and stable conditions with lower values of $\sigma_\theta$ during night time are the prominent features. Monsoonal months showed neutral stability for most of the time. A study $\sigma_\theta$ of and Pasquill Stability category has revealed the difficulty in giving a unique value of for each stability category. For the first time regression equations have been developed relating mixing heights and $\sigma_\theta$. A closer examination of $\sigma_\theta$ revealed that half of the range of wind direction fluctuations is to be taken, instead of one by sixth, to compute $\sigma_\theta$.

The spatial distribution of $SO_2$ showed a more or less uniform distribution with a slight intrusion towards south. Winter months showed low concentrations contrary to the expectations. The variations of the concentration is found to be influenced more by the mixing height and the stack height rather than wind speed. In the densely populated areas the concentration is more than the threshold limit value. However, the values reported appear to be high, because no deplition of the material is assumed through dry or wet depositions and also because of the inclusion of calm conditions with a very light wind speed.

A reduction of emission during night time with a consequent rise during day time would bring down the levels of pollution. The probable locations for the new industries could be the extreme southeast parts because the concentration towards the north falls off very quickly resulting low concentrations. In such a case pollutant spread would be towards south and west, thus keeping the city interior relatively free from pollution. A more detailed examination of the pollutant spread by means of models that would take the dry and wet depositions may be necessary. Nevertheless, the present model serves to give the trend of the distribution of pollutant concentration with which one can suggest the optimum locations for the new industries.

## M.S.68. SUBHASH CHANDRA SONI–Pathological Investigations in Penaeid Prawns–1986–Dr. P. Vedavyasa Rao

As a result of the survey, ten cases of diseases and abnormalities are reported. These include tumour-like growth, "soft" prawn syndrome, tail necrosis, brown spot disease, red rostrum, ciliate infestation, microsporidiosis, helminth parasitisation, metacercarial infestation and bopyrid infestation in the penaeid prawns such as *Penaeus indicus, P. monodon, P. semisulcatus/ Metapenaeus dobsoni* and *M. affinis.*

The disease caused by the microsporidien parasites, commonly known as "cotton" or "milk" shrimp disease, and encountered in the wild juvenile an adult population of *P. semisulcatus* and *M. affinis* exploited off Rameswaram, Mandapam and Tuticorin on the southeast coast of India is selected for detailed investigation.

The nature, structure and characteristics of the different developmental stages and spores as studied by the light and electron microscopy and histological techniques of the microsporidian parasites collected from *P. semisulcatus* and *M. affinis* have revealed that they belong to three species, two of them assignable to the Family Thelohaniidae (Order: microsporida; Sub-order: Pansporoblastina) and the other one to the Family Pereziidae (Order: Microsporida; Sub-order: Apansporoblastina). Further detailed studies and comparisons with the described and known microsporidian species have revealed that they are new to Science.

The histopathological investigation on *T. semisulcata* infected prawns revealed that *T. semisulcata* is an intracellular parasite and highly pathogenic in nature. The effect of the pathogen on the cellular structure of the important organs such as gonad, hepatopancreas, body muscle, midgut, heart, optic nerves, retina and gills is studied.

The results indicate that the pathogen follows oral route of transmission and does not require any intermediate host. However, the spores of *S. somisulcata* have to undergo a process of conditioning by passing through the gut of the prawn before being capable of infecting the prawn. The initial site of infection by *T. semisulcata* is found to be the midgut.

## M.S.69. PRADEEP, R.–Studies on Bacterial Indicators and Pathogen in Cochin Backwater–1987–
## Dr. P. Lakshmana Perumal Swamy

During recent years the use of marine and estuarine ecosystem for the disposal of sanitary and industrial wastes has increased greatly. Due to overloading the self purification power of the sea, these aquatic ocosystems are getting eutrophied giving ample chances for the survival and growth of sewage borne microorganisms. In tropical situations, the range of hazard is wide including infections arising directly from water contact or from consuming uncooked or undercooked sea foods.

The range of presence of bacterial indicator organisms in an aquatic environment determines the extent of sewage pollution and portrays the suitability of the environment for recreational or fishing activities. Studies on bacterial indicators in Cochin backwater are scanty and information on the seafood borne pathogen *Vibrio parahaemolyticus* in the above environment are rare. The present investigation was carried out to determine the extent of faecal indicator bacteria and *Vibrio parahaemolyticus* simultaneously in this backwater system. The main objectives of the study was to findout whether there exists any significant relationship among bacterial indicators and *V. parahaemolyticus.* Further, influence of various environmental parameters on these indicators and pathogen, and some experimental studies on *V. parahaemolyticus* were also in view.

The thesis contains six chapters. First chapter forms the introduction covering preface, review of literature and objectives of the present study. Chapters, two and three describes the ecology of faecal indicator bacteria and *V. parahaemoloyticus* respectively. Experimental studies on selected *V. parahaemolyticus* isolates were discussed in fourth chapter. In chapter five a general discussion bringing information on seasonal variations of bacterial indicators and *V. parahaemolyticus* collectively were presented. The entire work is summarised in sixth chapter bringing salient findings. Apart from these, references and list of publications are also included.

In the preface section the role of bacterial indicators in sanitary evaluation of environment is presented. Review of literature covers the evolution of coliforms, *Escherichiacoli*, streptococci and *Vibrio* spp. as indicators of pollution through chronological corridors. This chapter also includes relevant works done on *V. parahaemolyticus* in India and abroad. The major objectives in undertaking this work were 1) to monitor the population dynamics of bacterial indicators (total coliforms, faecal coliforms, *E. coli* and faecal strepatococci), *V. parahaemolyticus* and allied organisms, in water, sediment, zooplankton, fish and prawn collected from Cochin backwater, 2) to ascertain the influence of hydrobiological parameters on the seasonal distribution of these indicators and pathogen, 3) to findout whether there exists any significant relations between these indicators and pathogen in their distribution pattern, 4) to characterize *V. parahaemolyticus* isolated from this ecosystem along with reference cultures, 5) to findout the influence of varying temperature, pH and NaCl concentration (individually and collectively) on growth of selected *V. parahaemolyticus* isolates and 6) to determine the sensitivity/resistance pattern of *V. parahaemolyticus* to various antibiotics and heavy metals.

In the second chapter, details of sampling stations, collection of samples, estimation of physico-chemical parameters, preparation of samples and enumeration of faecal indicator bacteria and their results are presented. The data show that faecal contamination in Cochin backwater has crossed the permissible limits. Faecal index in fish and prawn exhibit that there is high risk of enteric disease outbreaks in consuming them. Monsoon rains influenced the distribution of bacterial indicators in water and sediment.

In chapter three ecology of *V. parahaemolyticus* and allied organisms in this backwater are presented. Enumeration of *V. parahaemolyticus* and allied organisms, their seasonal variations and influence of hydrobiological parameters on them are detailed in this chapter. In spite of occassional disappearance from few samples *V. parahaemolyticus* were consistently present in all samples throughout the study period. This warrants strict precautionary measures in preparation and processing of sea foods. Distribution of this pathogen in water and sediment were influenced by salinity and pH while in fish and prawn they were independent of environmental parameters. Zooplankton blooms influenced distribution of *V. parahaemolyticus* in them. No definite significant correlations were found between bacterial indicators and *V. parahaemolyticus*. However in sediment samples at station 1 *V. parahaemolyticus* showed significant negative correlations with FC, EC ($P < 0.01$) and FS ($P < 0.05$).

Fourth chapter is fully devoted to experimental studies done on *V. parahaemolyticus* isolates. In the first section of this chapter characterization experiments done on *V. parahaemolyticus* were presented. 120 isolates were subjected to about 85 tests which included various morphological, cultural and biochemical characters. Isolates from Cochin backwater were similar to those from Japan and U.S.A in more than 94% of the characters. In the second section two isolates of *V. parahaemolyticus* were tested for growth at various temperatures ( 5 – 45°C), pH (5-9) and NaCl concentrations (0.05–8%). An alkaline pH with salinities from 2-4% and temperature 20–40°C are found to be most favourable for growth of *V. parahaemolyticus*. These conditions are prevalent in Cochin backwater. In the third section selected *V. parahaemolyticus* isolates were tested for sensitivity to various antibiotics and heavy metals. Gentamycin and chloramphenicol are found to be the antibiotics of choice in controlling *V. parahaemolyticus*. High concentrations of metals like lead, molybdenum, zinc, iron and copper were tolerated by this bacterium. Each of these sections contained materials and methods, results and discussions separately.

In the fifth chapter a general discussion is brought in. This includes various interrelated aspects influencing the ecology of bacterial indicators and *V. parahaemolyticus* in this ecosystem. It also highlights the results of the experimental studies in relation to the ecological conditions prevailing in this ecosystem. Importance of this work from the view of public health and sea food industry are emphasised.

Sixth chapter summarises the objectives, salient findings and conclusions in a lucid manner.

## M.s.70. PRASANNAKUMAR, S.–Studies on sediment transport in the surf zone along certain beaches of Kerala–1987– Dr. P.G. Kurup.

The observed geometric changes of the beaches at various locations from Azhikode to Anthakaranazhi along the central part of the Kerala coast, the distribution of sediments of these beaches, the available wave energy potential, the wave induced flows and the computed littoral drift from the mean wave climates have been presentedd.

This study aims to understand the sediment transport along this stretch of the coast considering the increased problem of beach erosion in spite of attempts made to prevent or reduce erosion through construction of artificial shore protection structures such as seawalls and groins.

The beaches within Narakkal and Anthakaranazhi zones, in general, indicated near-cyclic behaviour, undergoing similar patterns of accretion andd erosion within each of the zones.

An examination of the wave climate of this coast shows that waves approaching the coast with deep water directions of 220°TN to 300°TN and with periods varying from 6 sec to 14 sec, contribute significantly in the complex littoral movement of sediments along this coast.

The changes observed in the sediment characteristics of these beaches show that, excepting the beaches in Fort Cochin zone, all the beaches in the remaining three zones are composed of sediments finer than fine sands.

The presence of calm and muddy water in patches off Narakkal and Malipuram affect the kinematic viscosity of the waters.

The computed littoral sediment transport for the rough and fair weather seasons indicates a net southerly transport within the surf zone alone both the littoral cells.

This study indicates clearly that the sediment movement along the beaches bordering these barrier beaches is not a continuous process but is confined to more or less closed cells within which the sediment get recirculated.

## M.S.71. NOBLE, A-Some insights into the resource of the Indian Mackerel Rastrelliger Kanagurta (CUVIER)-1987-Dr. E.G. Silas.

Description of *Rastrelliger kanagurta* with keys to the identification of genus and species are given at the outset. An analysis of the production in India, and the maritime states are given amply illustrated and the status of mackerel in the marine fish catches touched upon. Seasonal distribution of mackerel along Indian coasts is studied and presented. Maximum catches in east coast occur in March in its north and April in south. On west coast, around southern most part it peaks in April-May. The fishery and biology of mackerel landed by *Thangu vala* at Cochin during 15 seasons falling between July 1965 and June 1980 were studied.

From mothly size distribution of mackerel in the commercial catches at Cochin the growth was found to be 15.07 mm per month in 1st year and 5.26 mm per month in the 2nd year. The length of fish at different age found out in the study are <159 mm 0-year, 160-229 mm 1-year, 230-269 mm 2-year, and >270 mm 3-year old. This age-length structure was fitted into a curve with von Bertalanffy's Growth Function. The commercial catches by *Thangu vala* accordingly comprised of 1-year old fish 72.5%, 0-year old 24.2%, and 2-year old 3.3% in the pooled value for the 15 seasons. The 3-year old occurred only in one season, that too in negligible numbers. From age composition, the total instantaneous mortality (Z) was claculated to be 3.2522. It was further apportioned to instantaneous fishing (F) and natural mortality (M) as 2.0814 and 1.1708 respectively. The rate of exploitation accordingly is 0.6152.

Between effort of *Thangu vala* and its cpue of mackeral, the regression relation gives a negative 'a' and a positive 'b' value indicating the fishing by this unit not to affact the stock. This relation hence cannot be used for yield studies. The growth parameters like $L\infty$, K, and $t_0$ were therefore computed and found to be 315 mm, 0.6 and ¯0.141 respectively. The average yield in India, during 1969-'80 representng a unit time in 10-year cycle in the long-term-fluctuation of the fishery, is 87,257 tonnes; and the standing stock (Y/F) and annual stock (Y/U) are calculatedd to be 41,922 and 141,835 toness respectively. The potential yield at F *Max* 5 is 209,820 tonnes and the maximum recorded all-India catch of 204,575 tonnes is within its limit.

## M.S.72. V. KRISHNAMURTHY-Microbial Flora of Selected species of crustaceans-1987-Dr. C.T. Samuel

The study dealt with the bacterial flora of a few selected commercially important species of prawns caught from Cochin backwaters. *Pendeus indicus* and *Metapenaeus dobsoni* are the most abundant species. Other prawn species that contribute to the prawn fisheries are *Penaew monodon, Metapenaeus affinis, M. monoceros, Macrobrachium rosenbergii* and *M. idella.*

Quantitative and qualitative studies of bacteria, their reaction to different biochemical tests, effect of different incubation temperatures on the bacterial load and the occurrence of bacteria of public health significance were studied. Gram negative bacteria belonging to the genera *Pseudomonas, Acinetobacter* and *Vibrio* were the most abundant in the prawns from Cochin backwaters. *Salmonella* was present in prawns and in the water samples and the sediment samples from the Cochin backwaters.

The study revealed that the bacterial counts on the body of the prawns were within acceptable limits. Though the incidence of bacteria of public health significance in prawns, water and the sediment was noticed, the counts were not large enough as to cause any public health hazard.

## M.S.73. BRIGHT SINGH, I.S.-Studies on the Bacteria Associated with Penaeus Indicus in a Culture System-1987-Dr.D. Chandramohanan and Dr. P. Lakshmana Perumal Swamy

The thesis deals with the quantitative and qualitative aspects of the heterotrophic bacteria associated with eggs, nauphii, zoea, mysis and post larvae in hatchery; juveniles and adults in a culture pond and post larvae, juveniles and adults in their natural habitat.

In hatchery, it has been observed that THB declined as the eggs hatched out and nauplii metamorphosed to post larvae through zoea and mysis. An increase in the percentage occurrence of *Vibrio* and the declining in generic diversity indices were the other prominent bacteriological changes taken place in eggs and larvae as well as in water during the rearing period. During the early stages (eggs and nauplii) *Pseudomonas* and *Acinetobacter* were dominant.

The study reveals that the *Vibrio* are active hydrolytic enzyme producers including chitinase. Similarly, higher temperature prefering Vibrios were also associated with post larvae.

In culture pond, the genera encountered with juveniles *Vibrio, Pseudomonas, Maraxella, Micrococreus, Bacillus* and coryneform group and with water *Vibrio, Pseudomonas, coryneform group, Moraxilla, Acinetobacter* and Enterobacteriacea, in the decreasing order of dominance. The stomach content showed a higher bacterial population than the surface sediment with more *Vibrio* and *Pseudomonas* where as in sedimant *Bacillus* and coryneform groups were dominant. Heterptrophic bacteria was found to be increasing in the intestine as the food passed through the alimentary canal. Besides in the intestine the percentage of *Vibrio* was double the percent seen in stomach. This investigation shows that the micro-environment of prawn alimentary canal is highly suitable for *Vibrio*, where it undergoes a few cycles of division.

Proteolytic and amylolytic bacteria were found to be dominant in happa as well as in culture pond. Majority of isolates of *Vibrio* elaborated chitinase.

Hiterotrophic bacteria exhibited a shift in the requirement of NaCl from 7 to 1% from the day of stocking to the time harvest. However, majority of *Vibrio* from the alimentary canal of prawns preferred 7% NaCl as optimum.

In the natural environment, a significant increase of the total heterotrophic bacteria and a remarkable generic shift leading to the dominance of *Vibrio* could be seen in post larvae, juveniles, adults, water and sediment from November to

May. Stomach content of adults harboured a higher bacterial population than surface sediment and exhibited *Vibrio* as the dominant genus indicating the animals selective feeding behaviour.

Majority of isolates were proteolytic followed by lipolytic; amylolytic and chitinolytic. The only dominant group which produced chitinase was *Vibrio.*

While majority of the isolates fall under the group preferring NaCl concentrations ranging from 1-3%, a considerable percentage preferred to grow at 7 to 10% NaCl.

Bacteria which could grow to maximum at a temperature ranging from 10 to 50°C could be isolated. It can be concluded that diverse physiological groups of bacteria with various optimal conditions for maxmimum growth exist together.

## M.S.74-P.GOPALAKRISHNA MURTHY–Studies on Thermal Structure in the Seas Around India–1987–G.S.Sharma

To understand the influence of the regional particulars of north Indian Ocean on the subsurface thermal structure, the variability of thermal field in spatial and temporal domains is to be studied on a finer resolution. The thesis investigates on these aspects for the Eastern Arabian Sea and SW Bay of Bengal.

The available BT data (upto 1979) in the region 5-24°N, 65-90 E, after quality checks are averaged over 2 - degree spatial grids on a monthly basis separately for coastal and deep waters. This material is used to document the seasonal variability of thermal field in the upper 275 m. The time series data sets consist of temperature, salinity and surface marine meteorological parameters sampled at finer resolution (5 to 180 minutes) from anchored/drifting ships over a few places in the coastal and deep waters in the seas around India. They are utilised to study the short-term thermal variability at these positions. A larger data base, coastal and off shore thermal feature north of 16 N and internal wave characteristics form the improvements over earlier works.

The annual cycle of temperatures in the surface layer (30 m) exhibits a bimodal oscillation in the entire coastal region and deep waters in 8-16 N as a result of secondary warming during Oct./Nov. and unimodal in the remaining areas. A higher annual range of temperature in this layer over northern regions (5.5 C compared to 2-3 C south of 16 N) emerges out of winter cooling. The seasonal warming (Mar. - May & Oct. - Nov.) penetrates upto about 50m and the cooling under upwelling (5 C) surpasses monsoonal cooling (2 C).

The waters in the upper 150 m column are highly sensitive to periodically shifting upwelling and downwelling processes. The upwelling commences at subsurface levels during Feb./Mar. remains active during summer monsoon and ceases by Sept./Oct., while sinking prevails during winter monsoon. A time lag of 2-3 months is noticed for the onset of upwelling in northern regions. The upwelling in the coastal region is invariably accompanied by sinking in the deep waters and vice-versa. Relaxation of upwelling is observed at some coastal places during Aug./Sept. In southern regions the upwelling is more intensive as well as extensive (20–30m/month and 400 km compared to 17–20 m/month and 200 km north of 16oN). The thermocline region off Cape and Srilanka is characterised by Rossby/Kelvin waves with periods of 2–4 months.

The short-term variability of temperature reveals internal waves of following. characteristics.

| Parameter | Long period | Short period |
|---|---|---|
| Amplitude (m) | 15–20 | 3.0–5.0 |
| Period (hrs) | 09–25 | 0.3–0.9 |
| Speed (m/s) | 0.8–1.3<br>(at depths of 50 & 70 m) | 0.4–1.0<br>(at depths of 10 & 50 m) |
| Wave length (Km) | 45–77 | 0.4–3.0 |
| Brunt vaisala frequency (cph) | – | 10.0–30.0 |
| Mode | First order | Second order |

The FFT analysis indicates harmonics of 4 hr multiples for long-period and 0.3 hr multiples for short-period internal waves with 15–50% energy concentrated at tidal frequencies. The long-period internal waves seems to be forced by tides and short-period internal waves by local wind field.

The results of this study are applicable in fishery exploration, weather prediction, underwater surveillance, ocean thermal energy, offshore drilling and pollutant dispersal.

## M.S.75. GOPAL, C–Nutritional Studies on Juvenile penaeus indicus–1987–Dr. R. Paul Raj.

The present study was carried out to determine the requirement of protein and water-soluble vitamins in the diet of juveniles of the Indian white prawn *B. indicus*, using purified diets, and to evaluate the nutritive value of a few plant an animal protein sources for the same species.

Data on survival, grwoth, specific food consumption, food conversion ratio, protein efficiency ratio and biochemical composition of the prawns wre collected from these experiments. Observations were also made on molting, food intake, response to photo-stimulus and changes in external morphology of the prawns. In few experiments, ammonia excretion by prawns was also recorded to elucidate the effects of experimental diets on excretion rates. Observations were also made on the histology of selected tissues of prawns from the experiments on ascorbic acid and choline requirements. Besides these, specific and non-specific symptoms observed in prawns, associated with deficiency or excess of the selected water soluble vitamins, were recorded.

Deficiency of sub-optimal levels of protein in the diet significantly affected the growth, survival, ingestion and utilisation of food and protein and general maintenance of body functions in prawns. Prolonged period of protein deficiency induced cannibalistic tendencies in prawns and resulted in near complete wiping of prawn population.

The optimal protein requirements of these juvenile prawns was found to be within the range of 35-40%.

Supra-optimal levels of protein (beyond 40% protein) in the diet had deleterious effect on growth, survival, body composition and utilization of food and protein.

Excess of proteins in diets resulted in enhanced rate of protein catabolism resulting in increased ammonia excretion rates.

A mixture of animal protein sources proved to be a superior protein source when compared to only plant or mixture of plant-animal protein sources.

Amongst plant protein sources, soybean meal and ground nut oil-cake were found to be as good as many of the animal protein source in promoting survival, growth and feed efficiency.

The protein sources of crustacean origin, namely the prawn meal and crab meal were found to show better food conversion ratio and protein efficiency ratio amongst all animal protein sources tested.

The purified diet was used as reference diet and it produced better survival and growth.

The deficiency of ascorbic acid, thiamine, niacin, pantothenic acid, inositol, riboflavin and choline in the diets severely affected the survival and growth of prawns. All these water-soluble vitamins were found to be indispensable for these prawns.

The findings clearly suggest the essentiality and optimal requirements for protein as well as water-soluble vitamins in the diet of juvenile *B. indicus.*

## M.S.76. –ROSAMMA PHILIP–Studies on proteolytic bacteria in fish spoilage–1987–Dr. P. Lakshmana Perumal Swamy

Total heterotrophic and proteolytic bacterial population of water, sediment, prawns *(Penaeus indicus* and *Metapenaeus dobsoni),* clams *(Sunetta scripta* and *Meretrix casta)* and fishes *(Etroplus suratensis* and *(Liza* parsia) were estimated for a period of one year. Analysis of the generic composition of the total heterotrophs showed that among the 1315 isolates majority were *Vibrio* (48.14%) followed by *Micrococcus* (13.23%) and *Pseudomonas* (10.95%). *Vibrio* was the dominant genus in water, sediment, prawns and fishes. In clams, besides *Vibrio,* the predominance of Enterbacteriaceae and *Micrococcus* was noticed. In general among the proteolytic forms also *Vibrio* was the dominant genus in the various samples followed by *Pseudomonas, Bacillus Micrococcus* and Enterbacteriaceae.

The spoilage potential of all the proteolytic bacteria were tested in various flesh media (prawn, clam and fish). It was observed that 91.73%, 75.33% and 32.02% of the isolates were capable of increasing the PH of the prawn, fish and clam flesh respectively. A majority could develop acidity in clam flesh and some maintained neutral PH in all the three media. An average of 71.21% were able to form ammonia in the flesh media. 54% of the proteolytic bacteria were capable of reducing TMAO to TMA - and 18.13% produced indole.

Four potential spoilers were selected for further study. They were *Pseudomonas* sp Ca 173, *Pseudomonas* sp Ca 386, *Vibrio* sp Ca 377 and *Vibrio* sp Ca 761. Generation time of these isolates were found to be comparatively shorter in the various flesh media depicting its fast multiplication rate and thereby reflecting the spoilage calibre. Growth and survival of these strains at different temperature, PH and NaCl in various media such as prawn, clam and fish flesh broth and nutrient broth were studied. Maximum survival was observed in different media for different strains and this suggest the varying protective effect offered by the different media.

Effect of temperature, PH and NaCl concentrations on the growth and protease formation was noted. All the four isolates grew well and produced maximum protease at 30°C except *Pseudomonas* sp. Ca 173 which preferred 35°C. Optimum PH for growth and protease production was PH7. Maximum growth was observed at 1% and 2% and NaCl for both *Pseudomonas* spp and *Vibrio* spp. respectively. However, the protease production was maximum at 0% NaCl. Study on the time course of growth and protease production at different PH, temperature and NaCl concentrations showed that the enzyme production starts considerably when the cells enter the stationary growth phase.

The maximum protease activity was displayed at different temperature (30-50°C) by various strains. The protease of all the four strains were stable at 0 to 40°C for 120 M. At 50°C the proteases of *Pseudomonas* sp. Ca 173 and *Vibrio* sp. Ca 377 were stable. The optimum PH for the protease activity of the four isolates was around 7. All the proteases were generally stable at PH 6 to 8. Sodium chloride plays a major role in the activity and stability of the proteases. The protease of *Pseudomonas* sp. Ca 173 and *Vibrio* sp. Ca 377 did not show much variation in the enzyme activity with the addition of NaCl (upto 5%) and was found to be stable at this range where as *Pseudomonas* sp Ca 386 and *Vibrio* sp. Ca 761 were severely affected with the addition of NaCl and the maximal activity was observed at 0% NaCl.

Growth and flesh protein degradation by the selectedd strains were studied using prawn, clam and fish flesh media and casein media. The strains preferred different media for their maximum growth and protein degradation. During the first 12 hrs. of incubation, the growth of all the strains was found to be maximum in the prawn flesh broth which might be due to the increased level of free amino acid. It was further noticed that the protein degradation commenced considerably on the third day and progressed rapidly during the following days marking the first 2 days as a phase of inactivity as far as the proteolysis is concerned.

The present investigation suggests that majority of proteolytic bacteria associated with prawns, clams and fishes are potential spoilers and at ambient conditions they may cause serious damage to the flesh and bring down the nutritional quality of seafoods.

## M.S.77. ANURADHA KRISHNAN–Studies on larval nutrition in the pearl oyster *Pinctada fucata* (Gould)–1987–

## Dr. K. Alagar Swamy

Larvae for the experiments were obtained from spawning of pearl oysters that were brought either from the pearl banks of the Gulf of Mannar or from the CMFRI pearl oyster farm. Spawning was mostly natural and in some cases induced by pH stimulation.

Results indicated that the density of larvae in the culture has an influence on growth and setting. Relatively poor growth and setting were observed at very low densities (1/ml and 3/ml) or high densities (8/ml and 10/ml). Density of 5 larvae/ml was seen to be optimum for larval rearing.

Maintaining larval density at 5/ml, two species of algae, namely *I. galbana* and *Pavlova (=Monochrysis) lutheri,* were independently fed to pearl oyster larvae at four increasing cell concentrations from 10 to 100 cells/μl. For both species, maximum growth was observed at the cell density of 25 cells/μl. With *I. galbana,* setting was maximum at 25 cells/μl and with P. lutheri at 10 cells/μl.

Good larval growth with *S. salina* and *T. gracilis.*

Based on the larval growth regression values (log $\mu$m per day) obtained for different diets, a food value index was prepared to rank the tested diets for nutritional value.

**Estimation of filtration rate**

The rate of filtration of algal cells by pearl oyster larvae was measured at four increasing cell concentrations of *I. galbana* between 10 and 100 cells/$\mu$l. It was observed that filtration rate increased with larval growth and decreased with higher cell concentration.

Two types of non-living diets, namely, freeze dried *I. galbana* and carrageenan bound microparticulate diet (CBMD) were evaluated for their nutritional potential to pearl oyster larvae. Freeze dried *I. galbana* was found to be a promising source of nutrition for the later stages of larval development and not for the earlier stages The response to CBMD was very poor and did not result in larval metamorphosis.

The increase in total organic matter from the D shape stage to the eyed umbo stage was largely in the form of protein and lipid and to a lesser extent in carbohydrate. With the onset of metamorphosis, levels of lipid, protein and carbohydrate were seen to decrease.

Consumption of algal cells was greater at the higher temperatures (28°C and 32°C). The influence of salinity in the range 26.0–38.1% on larval growth and setting was not notable. Within the pH range of 7.5–9.0, maximum growth and setting was observed at 8.1 (ambient pH).

Spat production increased when the antibiotic was added to the rearing medium. Aeration depressed growth rate when introduced during the D shape stage but enhanced growth and setting when introduced during the eyed umbo stage. The continuous flow ,system was beneficial in rearing post-umbo stages resulting in increased spat production.

## M.S.78. LATHA THAMPURAN–Physiological Effect of Copper (11) on *Sunetta Scripta* L. –1987–Dr. R. Damodaran and Dr. P.N.K. Nambisan

Many of the aquatic invertebrates especially bivalves capable of concentrating heavy metals and other contaminants have been proved useful in assessing the pollution of the marine environment. Hence, bivalve mollusc *SUNETTA SCRIPTA* is chosen for investigating the toxic effects of the heavy metal copper.

Influence of salinity on the oxygen consumption rate of the animals was investigated by the experiments conducted at $20 \times 10^{-3}$, $25 \times 10^{-3}$ salinities. From the results of the experiments conducted with different copper concentrations (1 and 2 mg $1^{-1}$ it is observed that the copper induced reductions in oxygen consumption rate were more pronounced in higher salinities and became less obvious in lower salinities when compared to the control values. The rate of filtration and body weight showed a linear relationship while the filtration rate (per mg of the body weight) is observed to decrease with increasing body weight. On comparison of the filtration rates obtained under the three different experimental salinities the copper induced reduction in filtration rate was slightly greater in higher salinities than in low salinities, when compared to the control values.

It was observed that, of the five different tissues investigated (gills, mantle, viscera, foot & aductor muscle) the gill tissue had considerably very high concentrations of the metal in all the three size groups (20–25 mm, 30–35 mm and 40–45 mm) at all times. The efficiency of accumulation was also observed to be highest with the gills under almost all the experimental conditions. Next to the gills, mantle had the greatest amount of accumulated metal which is followed by viscera. The lowest efficiency is exhibited by 'foot' while aductor muscle is seen to be more efficient when compared to 'foot'.

Salinity, an important environmental parameter is also known to exert its influence on the copper-bioaccumulation of *S. scripta.* Even though 'body size' of the organism is not seen to exert a significant influence on the rate of uptake of copper, the uptake rates were observed to decrease slightly with increasing size of the clams.

The animal's capacity to concentrate copper to very high levels in body tissues makes it fit for monitoring the effects of pollution load as well as for chemical analysis.

## M.S.79. CHANDRA PRABHA, A.C.–Studies on Oxygen Minimum Layer in the Arabian Sea in relation to Oceanic Circulation–1987–Dr. G.S. Sharma.

The thesis is an attempt to study the unique and peculiar characteristic features of the oxygen minimum layer occurring at the shallowest depths and also with lowest concentration in the Arabian Sea compared to any of the oceanic region in the world, in relation to the oceanic circulation.

The aim of the study is achieved by working out the topography of the oxygen minimum layer and also the oxyty within it.

The data for the present study mainly come from those collected on board different research vessels during the International Indian Ocean Expedition (1960–65).

In general, the oxygen minimum layer in the Arabian Sea mostly lies within the isanosteric surfaces of 180 to 220 cl/t and 200 to 240 cl/t during the southwest and northeast monsoons respectively, except very near the coasts particularly off Somalia and Arabia.

In the Arabian Sea, oxyty in the oxygen minimum layer showed southward increase during the southwest and northeast monsoons.

In the open sea, alternate cells of high and low oxyty are conspicuous especially during the southwest monsoon, as a consequence of cyclonic and anticyclonic circulation with hyperbolic points in between them.

The depth of the minimum layer decreases towards south. The oxyty on the isanosteric surfaces increases southward, while the isanosteric surfaces slope up southward.

An important feature observed during the southwest monsoon is the shallowest topography and high oxyty on all the surfaces, off Somalia and off the Arabia Coast.

The vertical advection is much less and it is the horizontal advection that mainly controls the minimum layer during the northeast monsoon compared to that during the southwest monsoon.

High oxyty waters from the south are transported towards north along the westernside of the Arabian Sea in the Southwest Monsoon Season.

The present study confirms the hypothesis of Wyrtki (1962) and is against the opinion expressed by Sverdrup (1938) and Sverdrup et al. (1941) that the biochemical processes control the oxygen minimum layer.

## M.S.80. SUBHASH CHANDER–Studies on Ecophysiology of *Penaeus indicus* H. Milne Edwards in the Grow-out System–1987–Dr. A.D. Diwan.

The present work was undertaken to understand the crustacean ecological niche, and its interactions with the animal's physiology.

In present study the main emphasis was to find out if seasonal variations of calcium, magnesium, phosphorus, copper and zinc in the water and sediment has any important role to play in altering the concentration of these elements in different tissues of prawn as evidenced by the seasonal studies in the grow-out as well as the sea ecosystem.

Two different ecosystems inhabited by *P. indicus* during its life i.e. a grow-out ecosystem comprising of 176 hectare estuarine impoundment located at Edvanakadu on Vypeen Island and connected to the estuarine complex of Cochin backwaters which remains marine dominated from November to May and a sea ecosystem located at about 30 m. depth isoline inshore area off Cochin where maturation and spawning process usually occur, more or less, for most part of the year.

The stress was on the study of seasonal dynamics of physicochemical characteristics of water and sediment and the influence of these dynamics on seasonal variations of metals in water and sediment in each ecosystem. Subsequently, the effect of seasonal variation of each metal in water and sediment on the seasonal metal dynamics in the prawn *P. indicus* was worked out in the respective ecosystem.

Three stations each, in the grow-out ecosystem as well as the sea ecosystem were selected. Samples of water, sediment and prawns (of maturing or mature stage) were collected every fortnight for a period of two years (i.e. from November, 1982 to October, 1984) from each station. It involved sampling of water, sediment and prawns from the sea ecosystem on board a research vessel of CMFRI as well as from the grow-out ecosystem on board a small boat.

The seasonal variation studies of different physicochemical parameters such as temperature, salinity, oxygen, hydrogen ion concentration, redox potential, nitrate, nitrite, ammonia, total phosphorus, primary productivity, calcium, magnesium, copper and zinc of water; and temperature, hydrogen ion concentration, redox potential, calcium, magnesium, total phosphorus, copper and zinc of sediment were carried out in each ecosystem. Simultaneously, seasonal variations of a few elements (i.e. calcium, magnesium, phosphorus, copper and zinc) in different tissues of *P. indicus* were worked out.

## M.S.81. SARALA DEVI, K–Effect of Industrial Pollution on the Benthic Communities of a Tropical Estuary–1987–Dr. R.V. Unnithan.

Cochin backwaters, a tropical barbuilt estuary is well known for its prawn, molluscan and demersal fisheries. Also it formed the dumping area for sewage, retting of husks and discharge of effluents from industries located on either side of it. As a result the fishery is being gradually dwindled year after year due to the lowering of the water quality. The effect of industrial polution on the benthic community of this tropical estuary was worked out. An area extending over 21 km from the mouth of the estuary to upstream of industrial belt was selected. Temporal and spatial variations of 16 environmental parameters at 9 stations along the area were monitored monthly during 1981. Benthic fauna of these 9 stations consisted of amphipods, polychaetes, isopods, tanaidaceans, molluscs and other crustaceans (Decapods, Acetes, Alpheids, Balanus, insect larvae, chironomid larvae, cumacea and some fresh water forms). Apart from these, sea anemone, flat worms, nematodes, sipunculoids, echinoderms and fishes were also encountered. 75 species belonging to 31 faunal groups were identified. Of these 31 groups, amphipods, polychaedes, isopods, tanaidaceans and molluscs were numerically abundant. Rest of the 26 groups (including 13 riverine forms) were found less significant due to their rare occurrence/low numerical abundance. Polychaetes and molluscs were the only major groups present at all the stations. Amphipods ranked 3rd in occurrence being present at Stations 1–7. *Paraheteromastus tenuis* (Capitellidae) a limivorous polychaete species very common in the retting yard was recorded from most of the stations. The spionid worm *Prionospio polybranchiata* a selective deposit feeder recognized as an indicator of organic pollution due to retting was recorded in low densities at Stations 2–7 indicating resilience to industrial pollution also. *Capitella capitata* constituting 98.8% of benthic population at Station 7 (immediately down stream of effluent discharge site) is proposed as an indicator of industrial pollution too. *Dendronereis aestuarina* present at all stations and at high densities at Stations 5, 6 and 8 can be considered as a pollution resistant species. *Lycastis indica, Paraheteromastus tenuis, Talehsapia annandalei,* Chironomid larvae and the molluscan *Pendora fluxosa* can be listed as pollution tolerant species.

The qualitative and quantitative distribution of benthic fauna was found to have a direct relationship with the type of the bottom and its physical nature. Distribution of species was examined using index of diversity (Fishers' Diversity index $\alpha$ and its variance V ($\alpha$) and Shannon-Wiener diversity function H (s) and MacAuthers coefficient of equitability. Cluster analysis showed with maximum affinity at 5% level at Stations 1 and 2 gradually reducing to effluent discharge point and an increase at Station 9 (Ref. Stn.).

The physico-chemical aspects deal with the spatial and temporal variations of the 16 environmental parameters studied *viz.* salinity, temperature, dissolved oxygen, $BOD_5$, COD, alkalinity, pH, ammonia, inorganic phosphate, nitrate, nitrite, suspended solids, particulate organic carbon, 'k' value, sediment characteristics and organic carbon. As these parameters could not predict the abundance of benthos independently interaction effects of parameter cluster were studied. In general the order of importance reduced from salinity, temperature, dissolved oxygen, $BOD_5$, nitrate and K. factor. Remaining parameters were of low significance.

Measurements of 12 parameters made at distances 10 m away down stream of the effluent discharge points showed considerable fall on values for all effluent characteristics. The results of studies on the water characteristics of the area indicated continuous changes as a result of large scale movements of the estuarine water under the influence of tidal forces, monsoon and land runoff coupled with its heterogeneous nature owing to the effluent discharged from the industries.

Studies on the impact of environmental parameters on the distribution of macrobenthos revealed the quantum of endurance warranted by the infauna to tide over the wide range of environmental stress. Low diversity and lower number of benthic fauna at the effluent discharge site may be due to the stress caused by the cumulative toxic effect of the effluents.

## M.S.82. Kandoran, M.K.–A Study of the Transfer of Technology in the Fish Curing Industry in India–1987 Dr. C.T. Samuel.

Three regions viz. Calicut (Kerala) and Malpe (Karnataka) in the west coast and Tuticorin (Tamil Nadu) in the east coast were selected for the study. Twenty eight dependent variables classified into six groups pertaining to fish curing technology were studied in relation to seven independent variables, viz: age, level of education, social participation, contact with extension agency, profitability of technology, income and debt.

Knowledge gap of fish curers in respect of fish curing technology was found to be 78.2% in Malpe, 74.17% in Tuticorin and 66.1% in Calicut. Average knowledge gap of extension workers was 44.35%

Fish curers having membership in one organisation registered the largest group in all the centres with 47.9% in Calicut, 56.8% in Malpe and 50% in Tuticorin. Fish curers having no membership in any organisation occupied the second position in Malpe with 17.6% and Tuticorin with 20% while in Calicut the second position was held by fish curers having membership in more than one organisation (20%).

The statistical analysis shows that variables like education, social participation, contact with extension agency, perception of profitability of technology, income and adoption rate are significantly and positively correlated each one another while all these variables negatively correlated with age and debt.

Community fish curing yards with service facilities on modern lines should be constructed in important fish curing centres by the Government Departments or other agencies for curing fish. Presence of middlemen should be minimised as far as possible by sale of cured fish through co-operatives and regulated markets.

Intensive training programmes should be organised on a systematic basis for training extension workers and fish curers frequently and effectively for continuous refreshment of their knowledge. Village level workers should frequently visit fish curing yards and give sound advice on technological problems. A sound mechanism has to be devised for transmitting the current and prominent problems in fish curing to the research system as a feed back for undertaking problem oriented research by scientists.

## M.S.83. SANTHOSH, K.R.–Theoretical Studies on Air Pollution Mateorology in South India–1987–Dr. D.V. Viswanadham.

Theoretical studies are necessary for estimating the probable concentrations of the air borne pollutants emitted from myriad sources, especially for planning stratagies. It is the atmosphere under different conditions that governs the pollutant dispersal once they enter it. The present thesis deals with the theoretical studies such as atmostpheric dispersal capacity, stability of the atmosphere, surface turbulence and modelling, for selected stations in South India. The thesis has been divided into six chapters.

**Chapter 1. Introduction.**

A brief introduction to the problem has been presentedd in this chapter.

**Chapter 2. Literature Survey, Materials and Methods.**

The published work on Air Pollution Meteorology has been reviewed briefly. The source of data and the details of the methods adopted for carrying out the present work have been presented in this chapter along with the merits and demerits of the methods adopted.

**Chapter 3. Atmospheric Dispersal Capacity Over South India.**

The vertical and the horizontal extent of the atmosphere to which pollutants can be dispersed are estimated for South India. The spatial, seasonal and the diurnal variations of mixing heights and ventilation coefficients have been presented together with the inversion studies. The three hourly wind roses have also been presented.

**Chapter 4. Atmospheric Stability and Surface Turbulence for Selected Stations in South India.**

The Pasquill's stability and its diurnal and seasonal variation has been presented. From the range of wind direction fluctuations, the surface turbulence has been estimated and its diurnal and seasonal variation has been studied. The inter relationship between mixing height, Pasquill's stability and surface turbulence has been studied.

**Chapter 5. Spatial Distribution of Pollutant Concentrations by Multiple Stack Gaussian Plume Model for Selectedd Centres in South India.**

The spatial distribution of the pollutant concentrations by means of multiple stack Gaussian plume model has been studied for four selected centres in South India. The optimum locations for new industries have been suggested.

**Chapter 6. Summary and Conclusions.**

A brief summary of the results of the present study is presented. The over all conclusions of the study have been presentedd in this chapter.

## M.S.84. ELIZABETH JOSEPH–Studies on the historical and biochemical changes during spermatogenesis in Mugil Cephalus Linnaeus and related species–1987– Dr. P. Vedavyasa Rao

The study aims to understand organisation of the tests, the pattern of spermatogenesis, spermatology and certain aspects of reprodductive physiology of the selected species as the information forms an essential pre-requisite for evolving successful breeding programmes, artificial fertilization and gamete preservation.

*Mugil cephalus*, the largest and the most important of the cultivated species of mullets was selected as the candidate species for investigation, and *Liza parsia*, one of the smaller varieties found abundantly in the Cochin Backwaters was chosen as the second species.

The structural organisation of the male reproductive system in the two species is described. On the basis of the morphological characters of the testes, a six stage maturity scale, comprising of immature, early maturing, late maturing, mature, oozing and spent stages was distinguished and adopted to describe the maturation process of the testes. The internal organisation and the distribution of the various cell types at each stage of maturity was studied by histological preparations. The results showed that the testes of both the species belonged to the lobular type with unrestricted spermatogonial distribution, as encountered in most teleosts.

The environmental factors such as salinity, temperature and dissolved oxygen of the surface waters of Cochin Barmouth, from where the material was collected, were monitored regularly and correlated with the condition factor and the gonado-somatic index (GSI) of the fish, to understand the influence of these environmental parameters on the reproductive cycle.

The sequential changes taking place in the testes during spermatogenesis and ultrastructure of each cell type namely, the primordial germ cell, spermatogonium, primary spermatocyte, secondary spermatocyte, spermatid and sperm were studied with the help of transmission electron microscopy.

The biochemical parameters such as protein, carbohydrate, lipid and cholesterol were estimated in the blood, muscle, liver and gonad at each maturity stage. The flucturations in biochemical composition of these tissues were found to closely relate to the stage of maturation of the. gonad.

The histochemical characteristics of the testes at various stages of maturity were studied through qualitative histochemical tests. The role of the specific types of proteins , carbohydrates and lipids that accumulated and depleted from the testes from time to time, during the process of spermatogenesis is discussed.

A preliminary study on the cryopreseravation of the milt of *M. Cephalus* and *L. parsia* was conducted during the present investigation. The mean sperm count in *M. cephalus* and *L. parsia* were estimated and the motility of sperms in the fresh and cryopreserved samples of milt was assessed by using a six point scale. Marine fish Ringer solution was used as the major extending medium with glycerine and dimethyl sulfoxide (DMSO) as cryoprotectants.

## M.S. 85–JOSEPH, M.G.–Studies on mixed layer depth in the Arabian Sea–1987–Dr. D. Sreenivasan

Mixed layer depth distribution in the Arabian Sea is mainly influenced by southwest and northeast monsoons and respective reversals of currents and gyre systems. The mixed layer depth characteristics in the Arabian Sea (between 10–25 ° N and 60–75°E) with sepcial references to its annual and short term predictability is the aspect of study in this thesis. Climatological data from the atlases of Wooster et al. (1967), Hastenrath and Lamb (1979) and Robinson et al. (1979) and BT/hydrometorological data collected during OCEANAVEX (1973-74), MONSOON (1977) and the local cruise of MV PRASIKSHANI have been analysed to present the variability of the mixed layer depth in relation to the causative factor like wind forcing, net heat transfer at sea surface, machanical/convective mixing, advection, convergence/divergence and internal oscillations. The study area was divided into 8 subareas of 5 degree quadrangles and the mean characteristics were studied. The thesis comprises of 6 chapters.

Distribution of surface wind field analysed indicated the dominance of southwest monsoonal wind forcing (May to September) by duration and severity in contrast to the northeast monsoon wind forcing (November to January). The monsoon controlled Arabian Sea exhibits unique characerisitics of bimodality in the annual signals of net heat transfer. SST and MLD brought about by the distinctive modifying features of strong summer heating, periodic upwelling and mid-summer surface layer cooling. Spring/summer heating is maxium (about 120 Wm $^{-2}$) and minimum off southwest coast of India (about 80 Wm$^{-2}$). While winter cooling is maximum in northern subareas (more than $-40$Wm$^{-2}$), annual maxium cooling (more than $-50$ to $-70$ Wm$^{-2}$) is observed in central and southern Arabian Sea. Biomodal annual SST variation with range 2–4°C reflected response delay of 1–2 months behind net heating cycle. Annual range in MLD variability revealed is about 5–195m on close grid analysis and 20–100m on coarser 5 degree mean analysis for the study area. Bimodal pattern in MLD variability is by shoaling during spring/summer heating and deepening during winter and mid-summer cooling. In the northern and east coastal subareas of study the secondary deepening in midsummer is supressed due to coastal divergence and upwelling processes. Mechanical and convective mixing values computed indicate that convective mixing closely describes the annual march of MLD in all subareas while wind mixing seems significant only during July-September (22-52m).

Advection influence area controlled by surface circulations of the changing monsoonal systems. Maxium current speeds (16-40 cm sec$^{-1}$). in the area occur during May-September, while currents are weaker during winter monsoon. In most of the subareas, deepening of MLD due to cooling in January and July-September is found to be augmented by covergence, inducing sinking. Similarly shoaling of MLD during heating in March-May for a significant portion of the study area is found supplemented by divergence causing upwelling. For long term predictive characteristics, difference in MLD given by wind (mechanical) and convective mixing could be reasonably reduced by incorporating convergence/divergence effects quantitatively evaluated in the study. Spectral analysis of internal oscillations revealed the possibility of amplitude perturbations of 1.5–3 m in the short period and 4–10 m in long period domains over predicted MLD during southwest monsoon period in the central Arabian Sea.

Spatial variability of MLD along 4 meridional sections suggested the influence of cyclonic circulation (anticlockwise) during December-February with dome shape in MLD topography and anticyclonic (clockwise) circulation during March-October. During winter, a warm cell (around 26°C) off Bombay and cold cell (around 23°C) off Pakistan/Iran were found to coincide with MLD trough (around 100m) and dome (around 110m) representing anticyclonic and cyclonic eddies respectively. During premonsoon regime, a warm cell of SST (around 30°C) off Bombay coinciding with MLD trough of anticyclonic eddy, cold cell (around

23°C) in the centre of northern Arabian Sea coinciding with MLD dome of cyclonic eddy and MLD troughs of anticyclonic eddies at the mouth of Gulf of Oman and off Kutch were also located. These imply importance of eddy interaction in prediction of MLD variability in the study area.

Lastly a one dimensional MLD prediction scheme (Laevastu, 1965; James, 1966) with assumptions of negligible advection and salinity gradient was used to predict short term variability of MLD both at shallow and deep sites in the study area. This proved reasonably good for predictions upto 6 hrs with only 5-10 m differences between predicted and observed MLD in 83% of 3 hourly predictions and 71% of 6 hourly predictions.

## M.S. 86. MANOHAR SIVARAM CHANDGE–Studies on lipid nutrition larvae and juveniles of the Indian white prawn penaeus indicus–1987–Dr. R. Paul Raj

Experimental studies were conducted in larvae and juveniles of one of the most suitable cultured species of Indian penaeid prawns, *Penaeus indicus*. For most of the experiments diets were prepared by using purified ingredients like casein, amino acids, sucrose, glucose, starch, soyabean oil, cod-liver oil, lecithin, cholesterol, vitamin mixture, mineral mixture and agar-agar or carrageenan as binder.

A completely randomised block design was selected for conducting the feeding experiments, with three replicates for each treatment and control. Data on various environmental parameters like salinity, temperature, dissolved oxygen, ammonia etc. were gathered regularly from the aquaria for each experiment.

Four sets of experiments were conducted to determine the dietary lipid requirements of larvae, post larvae 1-10 and 11-25, and juvenile prawns.

The results showed that the optimal lipid requirement of juvenile *P. indicus* may lie within the range of 9 to 12% of the diet.

Survival and growth data indicate that deletion of lecithin from the diet significantly affect larval survival and growth, thus indicating the essentiality of lecithin in the diet of larval *P. indicus* for normal survival. The optimal lecithin requirements for larval *P. indicus* appears to be about 2% in the diet.

To determine the essentiality and dietary requirement of lecithin by post larvae an experiment was conducted using graded levels of lecithin ranging from zero to 1.75% in the diet. The experiment, which was conducted with post larvae 11-25, showed that lecithin is an essential nutrient for proper survival, growth and utilization of food and protein. The deletion of lecithin from the diet significantly affect the growth, food conversion ratio, and protein efficiency ratio, thus demonstrating the essentiality of lecithin in the diet of juvenile prawns.

### Dietary requirement of fatty acids:

Four sets of laboratory experiments were conducted to study the effect of selected levels of fatty acids in the diets on the larvae, post larvae and juveniles of *P. indicus*.

All the larvae fed diets with purified linolenic acid died on the third day at protozoea 1 stage; whereas, larvae fed on the control diet (phytoplankton) metamorphosed and grew to post larvae 1 within 9 days. The larvae cannot survive on a diet with only linolenic acid, as essential fatty acid.

Experiments conducted to determine the linolenic acid requirements of post larvae 1-10 and 11-25 showed that survival and grwoth of post larvae are significantly influenced by the diets. The studies indicate that the fatty acids of the control diet lipids are superior to linolenic acid as fatty acid source in the diet of post larvae. Although growth of post larvae and juvenile prawns increase in dietary cholesterol, this increase in growth was not statistically significant.

### Evaluation of the nutritive value of lipid sources:

With a view to identifying suitable plant and animal lipid sources for formulation of practical diets for larvae, post larvae and juvenile prawns, the nutritive value of 13 naturally occuring lipids were evaluated. The fatty acids profile of dietary lipid source was compared with the fatty acids pattern of juvenile prawns to know the effect of dietary lipids on fatty acids composition of prawns.

Among the lipid sources, sardine oil, and a mixture of prawn head oil and sunflower were found to be relatively superior as lipid sources for better survival and growth of larvae of *P. indicus*.

## M.S.87. BABY, K.V.–Combined toxicity of heavy metals and petroleum hydrocarbons on selected marine organisms–1987–Dr. N.R. Menon

The effect of heavy metals (Hg, Cd and Zn) and Oils (HSD and BH Crude) singly and in combination on the life and activity of the commercially important marine bivalve, *Perna indica* has been worked out. The information available on accumulative and depurative processes in marine bivalves is reviewed to understand the present status of our knowledge in this field.

The instrumentation and chemical methods along with experimental design to study oxygen consumption, filtration, rate of byssogenesis, accumulation and depuration are presented. The statistical techniques utilised for the computation of the data are also described.

At lethal levels, mercury was the most sensitive toxicant, followed by zinc and cadmium. Among the WAFs, HSD proved to be more deleterious to *Perna indica*. The results on combined toxicity show that combination of Hg with Cd, Zn, HSD or BH Crude WAFs produced more than additive reactions uniformly. A comparable trend was shown when Cd was administered in combination with other toxicants. When Zn was administered at comparatively higher levels along with Hg or Cd, only simple additivity was manifested. On the other hand, Zn when present in combination with WAFs of HSD and BH Crude, resulted in more than additive reaction in bringing about lethality.

All the metals singly or in combination proved to be respiratory depressants, whereas comparatively lower concentrations of WAFs of HSD and BH Crude elevated respiratory rates.

The rate at which particles was filtered when *Perna indica* exposed to toxicants individually and in combination was also worked out. The metals singly or in combination deppressed filtration rate. Hg was the most toxic heavy metal and HSD WAF was more toxic than BH Crude WAF Combined toxicity gave mixed rates.

The rate of byssus thread production was indirectly proportioned to toxicant concentration. Here also Hg proved to be the most toxic heavy metal.

Rates of oxygen consumption and filtration by *Perna indica* exposed to heavy metals and oil, individually and in combination for periods upto 21 days were documented. The animals as a rule performed dicidedly at decreased rates when subjected to heavy metal and oil loads for periods from 1 to 21 days When returned to normal sea water, the animals could not regain normalcy which was found to be statistically significant.

## M.S.88. SIVADASAN, C.R.–Studies on the effects of selected trace metals on *Metapenaeus Dobsoni* (Miers)–1987–Dr. P.N.K. Nambisan.

The investigation is an attempt to determine the baseline concentrations of Hg, Cu and Zn in *Metapenaeus dobsoni* (Miers) a widely distributed prawn of Indian waters and to study the feasibility of *M. dobsoni* as a biological indicator of trace metal pollution.

The variation of Cu and Zn content in edible and nonedible parts of *M. dobsoni* collected during June 1984 to May 1985 was not appreciable but the Hg content varied with the season. Concentration of Cu and Zn in edible and nonedible parts showed significant positive correlation. Stratification of water and intermittent industrial effluent discharges seem to play the major role in controlling the trace metal concentration in the estuary than the seasonal variation in salinity. The trace metal content was within the specified limits for human consumption and these values form the basis for suggesting the basiline concentration of these metals in *M. dobsoni* form Cochin backwaters.

In acute toxicity tests, the adaptability of organisms to ambient conditions seems to have more influence on the toxic effects of trace metals. Hg was found to be the most toxic and the order of toxicity was found to be $\mathrm{Hg} > \mathrm{Cu} = \mathrm{Zn}$ The LC50 values determined for the different size groups at various salinities paves as a guideline in predicting the water quality criteria in pollution monitoring.

Studies on the kinetics of accumulation and depuration in *M. dobsoni* suggested a first order two compartment kinetic model. In the case of Hg, *M. dobsoni* was found to shed the Hg load after reaching a treshold concentration depending on the salinity of the exposure medium. Gill was found to be the major site of accumulation of all the three metals and the order of accumulation in different body parts was gill > viscera > exoskeleton > muscle. Accumulation was higher in lower size groups and this observation confirmed the hypothesis that smaller animals with large surface area to volume ratio accumulate trace metals faster from solution than larger ones. Two stage depuration mechanism with a rapid initial one followedd by a slow release was noticed for Hg and Cu. In the case of Zn, two compartment release was noticed with a very slow rate of release in the slow compartment. The biological half life ($t_{1/2}$) for Hg and Cu in the species were also determined.

On exposure to Hg and Cu, oxygen consumption was decreasd while the same was enhanced on exposure to Zn during the initial periods of exposure. The response of oxygen consumption was comparable to the rate constant values for accumulation. The influence of threshold values during accumulation was

reflected in the rate of oxygen consumption on exposure to Hg.

In the light of the observations made *M. dobsoni* conforms to the requirements of a sentinel organism in the estuarine environmental management and is recommended as an indicator organism of trace metal pollution for Indian waters.

## M.S.89. GOPAL PRASAD MAHOBIA–Studies on Indian cichlids–1988–Dr. K.C. George

The endemic Indian cichlids are represented by two species *Etroplus suratensis* (the pearl spot or green chromide) and *Etroplus maculatus* (the orange chromide). They occur along the coastal tracts of peninsular India and some of the land locked fresh water lakes of the country. *Etroplus suratensis*, the larger of the two is a delicious table fish and an important species for culture in brackish and fresh waters. Considerable attention has been given in recent years to research and development programmes relating to the culture of this fish. *Etroplus maculatus* due to its smaller size is of lesser economic importance as a cultivable fish. It is however caught in the wild and also reared as an aquarium fish.

In view of wide spread degradation of natural aquatic environments, often with decline or extinction of fish stocks, it has become important to evaluate the genetic diversity of fish resources. During the last decade considerable progress has been made towards understanding the genetic make-up variability of the wild as well as farmed fish stocks for the management and improvement of their genetic resources. However, our knowledge of these aspects in the Indian cichlids is scarce.

The study aims to clarify the taxonomical status of the species through study of morphometric and meristic variations and protein patterns variation of fishes from different geographical areas of peninsular India.

Attempts have also been made to understand the genetic make-up of populations of both species in Cochin back-waters through izoenzyme study and to see the variability in bio-chemical constituents of fish tissues during the life cycle.

Studies on chromosomes and induced breeding have also been made.

The material for study was collected from Cochin backwaters, estuarine areas of Mangalore, Karwar, Goa, Pondicherry, Muthukadu, Pulikat lake and fresh water lake of Hyderabad, during December 1981 to December 1985.

A review of the literature on bionomics, life history, the present state of fishery and the status of taxonomy of Indian cichlids have been presented.

Variations in morphometric and meristic characters of populations of different localities have been described. Morphometric study revealed that the populations of *Etroplus suratensis* in Cochin & Hyderabad and Kawar & Pondicherry are homogenous, since they showed no significant variation in respect of morphometric and meristic characters considered among them. Populations of Mangalore & Muthukadu, Mangalore & Pulikat lake, Muthukad & Pulikat lake and Karwar & Goa showed homogeneity in respect of only morphometric character; where as populations of Muthukadu & Hyderabad showed homogeneity in respect of meristic characters only.

Populations of *Etroplus maculatus* showed homogeneity in respect of the morphometric characters considered in Cochin, Muthukadu, Pulikat lake and Hyderabad, whereas in respect of meristic characters the populations were observed to be heterogenous.

The bio-chemical parameters such as moisture, protein, carbohydrate, lipid and ash were estimated in the blood, muscle, liver and gonad at each maturity stage. A close relationship was observed between the fluctuations in bio-chemical composition of these tissues with the stage of maturation of gonads. As the maturation of the gonads advanced there was a distinct drain of the body resources to the gonads.

Proteins and isoenzymes were studied electrophoretically in both species. Protein pattern showed variation among tissues, between sexes, maturity stages and in different size groups. Muscle protein patterns varied in different localities also. Expression of isoenzymes lactate dehydrogenase & esterase in *Etroplus suratensis* and for esterase & acid phosphatase in *Etroplus maculatus.*

Various dosages of hormones and steroids were tried to induce spawning in *Etroplus suratensis* in the laboratory conditions.

The present studies carried out on the morphological bio-chemical and chemotaxonomical aspects on the two species of Indian cichlids *Etroplus suratensis* & *Etrolus maculatus* form original contributions and considerably add to the present knowledge on cichlids. The results of this investigation it is hoped would help in the management and improvement of the aquaculture schemes of Indian cichlids and related species.

## M.S.90. UNNIKRISHNAN, V.P.–Texture, mineralogy and provenance of the beach sands of South Kerala–1988– Dr. Y.L. Dora.

A detailed sedimentological study of the beach deposits of the area from Azhikode in the north to Manavalakurichi in the south is embodied in this thesis. The beach sands of Kerala are world famous for the occurence of valuable placer minerals such as ilmenite, monazite, rutile, sillimanite, zircon, leucoxene etc.

The sedimentological studies on the 280 km long South Kerala beaches, subenvironments like backshore, berm, foreshore and low water mark and the fifteen westflowing South Kerala rivers were pursued with the following objectives.

This thesis consists of eight chapters. The general introduction to the area of study is given in the first chapter. Chapter II deals with sampling and laboratory techniquest. The geology and geomorphology of South Kerala beaches and drainage basins of various rivers are discussed in Chapte III. The beach processes and sedimentary structures along the South Kerala Coast are presented in Chapter IV. The results and discussions of the texture, mineralogy and provenance of beach sands and river sands are given in detail in Chapters V,VI & VII respectively. The eighth Chapter gives, in brief, the summary and salient conclusions of the investigations.

The size analysis reveals that the phi mean (z) and phi meadian (md) size decreases (grain size increases) towards south, ie. from Azhikode to Manavalakurichi for the four subenvironments of the beach, like backshore, foreshore, berm and low watermark. Majority of the sands are medium to fine in size. The standard deviation shows that its range is from 0.41 Ø to 01.37 Ø and no significant lateral variations are noticeable.

In general, the skewness (SKI) and Kurtosis (KG) show inverse relationship. Skewness ranges from positively skewed to negatively skewed and the majority are nearly symmetrical. The correlation among various statistical parameters shows no marked interrelationship except that the standard deviation increases with the decrease in kurtosis in all subenvironments.

The phi mean, phi median and graphic skewness of river sands also slightly increase towards south. Majority of river sands are coarse-grained in size. The river sands are predominantly either moderately sorted or poorly sorted, positively or negatively skewed and mesokurtic in nature.

The roundness studies indicate that roundness values increase from Azhikode to Manavalakurichi for 3 size grades of the backshore, foreshore and river sediments. Zircon shows a slight increase in its roundness towards south both in beach and river deposits. The other minerals have no noticeable lateral variations. Opaques, hornblends, sillimanite, garnet etc. show an increase in their roundness with an increase in size. In general, the beach sands are more rounded than the river sands.

Regarding the mineralogy, the study of the variations of heavy and light minerals shows that the percentage of heavies sharply increases with a decrease in grain size. Among the heavy minerals, monazite and zircon show marked increase in percentage with decrease in size grade. Among the non-opaque heavy minerals; while hornblend is the most dominating mineral in the northern parts of the study area, sillimanite is abundant in the central and southern parts. It is also noted that pyrozene decrease towards south. The lateral variations observed in the other heavy minerals are less significant. In general the river sands show a decrease in the percentage of heavies from the source to the mouth.

Quartz is the predominant (average 97.7%) among the light minerals in beach sands.

In order to decipher the provence of beach sands of South Kerala, the textural and mineralogical analyses were correlatedd with the results of textural and mineralogical analysis of samples from all the rivers of South Kerala. The correlation studies were carried out with the help of the mineralogical analysis of rock specimens collected from the drainage basins of various rivers.

## M.S.91. SARASU, T.N.–Larval biology of spiny lobsters of genus *Panulirus*–1988–Dr. M.J. George.

The spiny lobsters with their ever increasing demand as a delicacy all over the world have great importance in the commercial fishery. Through the export of products from this valuable Crustacean, a considerable amount of foreign exchange is earned by our country. The export oriented industry of frozen lobster tail production in India wholly depends on the commercial exploitation of the spiny lobsters occurring along Indian coasts, the important species exploited being *Panilirus homarus, P. polyphagus, P. ornatus* and *P. versicolor.*

In recent years considerable decline in the total production of these lobsters have been noticed indicating necessity for measures of conservation of fishery. One way of augmenting production is through artificial culture of the spiny lobster. This has attracted attention of researchers all over the world and various attempts have been and are being made to culture the spiny lobsters through all the larval stages in the laboratory. However, so far attempts to rear commercially important spiny lobsters from egg through all the phyllosoma stages and subsequent commercial culture have not been successful. To a large extent knowledge about the biology of the phyllosoma larvae remains to be revealed in order to make commercial culture possible. Development of culture systems largely depends on evolving an efficient technology for commercial rearing of the larvae.

Knowledge about the phyllosoma larvae of spiny lobsters of India is mostly limited to larval samples from nature through plankton collections. A few attempts have also been made by some authors to rear the larvae in the very early stages. Therefore the Indian spiny lobster *Panulirus homarus* was selected to study the larval biology by hatching the eggs in the laboratory and subsequent rearing of the phyllosoma larvae through the stages and also by conducting experiments to determine optimum conditions of environment to minimise larval mortality and ensure successful growth and moulting of the larvae. Phyllosoma larvae of defferent species sorted out from plankton samples collected during research cruises were also studied.

Fully alive berried specimens of the lobster *Panulirus homarus* for hatching and rearing experiments were collected from Kayalpattinam near Tuticorim during January 1984 to June 1986. The phyllosoma larval samples for analyses were obtained from the zooplankton samples collected during cruises of the Fishery & Oceanographic Research Vessel Sagar Sampada of the Department of Ocean Development, conducted off Indian coasts in 1985.

A brief review of the literature on biology, taxonomy and other features of spiny lobsters especially with reference to larval biology, phyllosoma larvae and culture has been presented.

By keeping live berried specimens in brood tanks in the laboratory successful hatching of the eggs were obtained several times. Experiments conducted on rearing the larvae giving *Artemia* nauplii and jellyfish as food and the different stages obtained are described. In spite of several attempts to rear the larvae through successive moults only 4 stages were obtained in the laboratory and these stages are described in detail. One important observation requiring mention is that more than one moult occurs between two stages.

The presence of the naupliosoma in the life history of *P.homarus* was confirmed, although it was observed that there is no moulting from this to the 1st stage.

Another result worthy of mention is the fact that *Sagita* and jellyfishes are acceptable to the phyllosoma larvae as food in addition to *Artemia* nauplii. It was also noticed that the major cause of the larval mortality was the lack of suitable food for different larval stages.

Experiments conducted to determine the influence of Salinity, pH, temperature and dissolved oxygen on the survival and moulting of the larvae in the laboratory yielded useful results. Statistical analysis of results obtained by rearing batches of phyllosoma 1st stage, larvae in sea water of different grades of salinity, pH, temperature and dissolved oxygen in triplicate experiments showed that the optimum salinity, pH, temperature and dissolved oxygen to be in the range of 28 to 30 ppt, 8 to 8.6, 31°C and 4ml/1tr. respectively.

Taxonomic studies on the phyllosoma larvae collected from the plankton indicated occurrance of different stages of larvae *P.homarus, P.versicolor, P.penicillatus, P. longipes, P.polyphagus* and *P.ornatus* in the samples analysed. The stages are described with ful details and figures in the thesis.

## M.S.92. SHADANANAN NAIR, K.–Hydrometeorological studies of Kerala State in relation to the Western Ghats–1988–Dr. H.S. Rammohan.

The thesis is a hydrometeorological appraisal of Kerala State in relation to the Western Ghats using the water balance concepts first developed by Thornthwaite. Data of monthly rainfall and temperature for the period 1901 to 1980 have been used for a hydroclimatic study of the entire Western Ghats region and a more detailed hydrometeorological study of the Kerala State.

The study reveals that the coastal belt between the Arabian Sea and the Ghats receives abundant rainfall, upto 600 cms. in some isolated locations in an year. Most of the rainfall occurs during the southwest monsoon season while the northeast monsoon rainfall is significant only in the southern parts. About 20% to 40% of the rainfall in the Ghats region is available for exploitation. However, in the central parts it is upto 60%. The leeside of the Ghats gets scanty rainfall only.

The State of Kerala lies on the western flanks of the southern portion of the Ghats. Here, the rainfall increases from 150 cms. in the south to more than 350cms. in the northern districts of the State. The number of rainy days increases from 90 in the north to 120 in the south, as a result of the influence of northeast monsoon in the south. Annual rainfall is more stable and reliable compared to the seasonal rainfall. In general, stations experiencing high rainfall exhibit more stability of rainfall than low rainfall stations. No periodicity is observed in the occurrence of annual rainfall departures in the drier or wetter directions.

Studies on the water balance parameters reveal that on an average, there exists an annual water need (potential evapotranspiration) of 170 cms. in the whole State whereas the actual evapotranspiration ranges from 130 cms. to 150 cms; an annual water deficiency of 25 cms. to 30 cms. exists. The annual water surpluses vary from 50 cms. in the south to 200 cms. in the north. Surpluses do not occur during pre-monsoon and winter months, but runoff occurs in all the seasons the maximum being in the southwest monsoon months. The surface runoff ranges from 30 cms. in the south to 100 cms. in the north. The underground flow is more than 100 cms. along the coast and between 20 cms. and 50 cms. in the Ghats region.

Studies of the drought climatology of the State reveal that all stations in Kerala have experienced droughts, including disastrous ones in about 50% of the years of study. But there is no evidence of any spatial coherence of droughts-droughts do not necessarily occur at the same time in the different parts of the State and even if many parts experience droughts in the same year, they are not of the same intensity. Therefore, it appears that most droughts over Kerala, even disastrous ones, are due to local variations in rainfall in different parts of the State rather than large scale anomalies in the general circulation over the region.

Studies of the climatic shifts show that the moisture regimes of different parts of the State undergo wide fluctuations, both towards drier and wetter directions. The water balance studies of the extreme dry and wet years and the years of disastrous droughts reinforce the idea that it is the distribution of rainfall and not the total amount that determines the water deficiencies or surpluses of a region. Even in the driest year, water surpluses do not altogether cease, but dificiencies rise to higher levels. Similarly, even in the wettest year, water deficiencies do occur, eventhough surpluses rise to high levels.

It is suggested that optimum utilization and careful management of the water resources are essential for the overall development of the State. The large water surplus and surface flow during southwest monsoon season can be harnessed for use during other seasons. Small check dams are more suitable in the Ghats than large hydrological projects because of the short length of river basins and steep slopes of the Ghats.

### M.S.93. KURIAN, N.P.–Wave Height and Spectral Transformation in the Shallow Waters of Kerala Coast and their Prediction–1988–Dr. M. Baba

The study of transformation of waves as they propogate from deep water to shallow water is essential in understanding and predicting the shallow water waves. The present thesis is an outcome of the investigation carried out by the author to study the wave height and spectral transformation in the shallow waters of Kerala Coast and to suggest prediction models suitable for this coast. A major handicap in the study of wave transformation has been the lack of synchronized deep and shallow water measured wave data. The study was carried out by making synchronised deep water and nearshore wave measurements at two locations, viz. Alleppey and Trivandrum, which have strikingly dissimilar wave climate, shelf slope and sediment characteristics.

From a study of the wave height transformation, it is found that attenuation of wave height takes place during propogation in the shallow waters. While the attenuation is less off Trivandrum, it is as much as 50% for waves of 2-3 m height off Alleppey. The differences in attenuation between the two locations are found to be due to differences in the energy dissipation by bottom friction which in turn is decided by the bottom slope and bottom roughness. Since bottom slope is found to be the dominant factor in the frictional dissipation, and consequently the attenuation of wave height and energy, it is used as the criterion for categorisation of the Kerala Coast into different zones of wave transformation. Study of spectral transformation also confirmed the energy loss during propogation in the shallow waters. In many cases during high energy conditions, the peak spectral density is found to increase, which may be due to the nonlinear wave-wave interaction. Multipeakedness is generally found both in deep and nearshore spectra. It is concluded that the secondary peaks in the observed nearshore spectra are due to sea waves only.

For the prediction of wave height transformation, the model by Dobson with its subsequent modification by Coleman and Wright to incorporate bottom frictional attenuation was chosen. This model was further modified to facilitate the simultaneous usage of two grids, the coarse offshore and the fine inshore grid. The inclusion of this fine inshore grid enables the accurate computation of wave transformation in the inshore where the effects of transformation are very pronounced. Computed results using this modified programme were compared with measured data and a high correlation of 0.8 is obtained. It is concluded that the programme by Dobson with the suggested modifications is suitable for the Kerala coast when used with a friction factor of 0.02. The extent of influence of bottom friction in the attenuation of wave height and energy was studied

using the computed friction coefficient. In addition to Alleppey and Trivandrum, the computations were carried out for Calicut for uniform deep water conditions. The percentage attenuations in wave height for deep water waves of height 2m and period 12 s approaching normal to the coastline are 7%, 52% and 74% respectively at Trivandrum, Alleppey and Calicut. This reaffirm the energy level categorisation of the Kerala Coast made earlier based on the bottom slope, which determines the bottom frictional dissipation. For prediction of nearshore wave spectrum, a spectral transformation model by Hubertz was chosen and modified to incorporate bottom frictional attenuation using the equations of Collins. The computations were carried out here also using offshore and inshore grids of depths. Computed nearshore spectra with a friction factor of 0.01 are found to compare well with the measured spectra. It is concluded that the model by Hubertz with the suggested modifications is suitable for the Kerala coast.

### M.S.94. NIRMALA THAMPURAN – Quantitative and Qualitative Studies on the Bacteriology of frozen fishes and prawns–1988–Dr. K. Gopakumar.

The thesis is concerned with a detailed study of the bacteriology of freezing of mackerel (*Rastrelliger kanagurta*) and prawn (*Metapenaeus dobsoni*).

True assessment of the bacterial load and accurate interpretation of the results depend on the methodology employed for the recovery of bacteria. Hence, factors affecting the recovery of bacteria from fresh/frozen fish and prawn were standardized for maximum recovery. The effect of plating methods, effect of temperature of incubation and period were studied in detail. The effect of diluent and the time for holding the homogenate in these diluents were also investigated. Fishes like oil sardine (*Sardinella longiceps*), mackerel (*Rastrelliger kanagurta*), mullet (*Mugil cephalus*), jew fish (*Johnius dissumeri*), prawn (*Metapenaeus dobsoni*) etc. were used for this part of the study.

The main purpose of the investigation was to understand the gross bacteriological changes occuring during freezing of fish and prawn. This necessitates a thorough knowledge of the background microbial flora of the fresh fish and prawn. Hence, a detailed study of the bacteriology of the newly caught fish and prawn was made. This revealed that the tropical fish and prawn harboured higher numbers of *Vibrio* spp. than the cold water fishes. The total bacterial population was also comparatively high.

The survival pattern at freezing temperatures −39 + 2°C and −20 + 2°C of major species of bacteria isolated from fish and prawn was investigated. Also the influence of interrelated factors such as pH, salt concentration, cell density and cold shock which govern survival at low temperature were studied. The study showed that maximum death occurred in the freezing phase. Death of lesser proportion occurred in the next ten days during frozen storage. Thereafter death was very gradual and almost linear curves resulted. Even after storage for up to one year at −39 + 2° C or −20 + 20°C sufficient numbers of bacteria persisted in many instances. The behaviour at these temperatures of pathogens such as *Salmonella anatum* was very much comparable to that of marine isolates. The Gram-negatives in general and *Vibrio* species in particular showed high sensitivity to low temperature. The Gram-negatives suffured death during freezing and subsequent storage period. In Gram-positive types death was more evident in the storage period.

Selected bacteria in mixed populations were frozen and stored at −39 + 2°C, and their survival was compared to that of individual cultures. *Pseudomonas* and *Micrococcus* exhibited similar pattern of survival individually and in mixtures. *Moraxella* showed a difference in survival pattern.

The freezing menstrum exerted a major influence on survival at −39 ± 2°C. It was found that fish muscle medium was very protective. The effect of initial cell number of bacteria on the survival at low temperature was evident only at high initial cell densities of the order $10^7$to $10^9$. The pH of the medium and age of cells also affected the survival. The minimum concentration of sucrose and glycerol which protected the bacterial cells varied with species. The metabolic injury occuring to selected bacterial isolates were determined at −39 ± 2°C and −20 ± 2°C. The growth rate during thawing of frozen cultures was also investigated.

Changes occurring both quantitatively and qualitatively in the native flora of mackeral and prawn during freezing and subsequent frozen storage were investigated.

Washing the raw material caused 52-98% reduction in the total bacterial count, while icing for short period caused no significant change in the bacterial flora of both mackerel and prawn. Removal of head of prawns decreased the bacterial count considerably. Icing resulted in a slight increase in the *Pseudomonas* species. Peeling and deveining resulted in increase in the number of Gram-positive cocci, especially *Microccocus* species.

Freezing of the fish and prawn at −40°C caused 70-80% reduction in the total bacterial count of the muscle. The intestine also registered ccorresponding decrease. Storage of fish and prawn at −20 ± 2°C for period up to one year caused a steady decline in the bacterial count. But the decrease was less (about 30%) and the values varied considerably. Among the various genera encountered in fish and prawn, the *Vibrio* species faced maximum destruction. Even though this group surpassed all other types in the native flora of mackerel, within one month they were completely eliminated from the system. The Gram-positive *Micrococcus* species showed significant resistance to death during freezing. The *Moraxella* species remained stationery, while *Pseudomonas* showed decrease in their relative proportion.

The changes in the various physiological groups of bacteria during freezing and frozen storage of makerel and prawn were also followed.

Thawing studies of frozen fish and prawn at temperature +4°C, +15°C and room temperature (29 ± 2°C) indicated a delay on the onset of growth and multiplication of bacteria in thawed samples. Quantitatively as well as qualitatively, the bacterial profile of the thaw drip was a reflection of the bacterial flora of the thawed muscle. *Pseudomonas* species were the terminal flora in mackerel while in prawn *Moraxella* was the main group at the time of spoilage of thawed fish.

The biochemical and spoilage characteristics of the isolated cultures from frozen and thawed mackerel and prawn showed *Pseudomonas* to be the most active. No relationship was observed between spoilage potential and biochemical activity. Influence of temperature on the biochemical activity was also studied.

## M.S.95. SURESH, K. – Haematology of some Marine and Estuarine molluscs of commercial importance–1988– Dr. A. Mohandas.

In recent years there is increased awareness regarding the potentiality of molluscan fishery as a good resource to provide protein and mineral-rich food. In intensive molluscan culture programmes, now adopted, set-backs because of bacterial, viral, protozoan and metazoan parasitic out-breaks are not uncommon. Bivalves are also peculiar in the sense that they have the capacity to accumulate potentially toxic heavy metals and micro-organisms in their bodies from the environments in which they habits, serving as vehicles for the transmission of diseas to man. A knowledge about the mechanisms involved in these processes will answer seveal problems of public health importance. Yet another important aspect that needs emphasis is the utilization of marine organisms as models for research directed at understading the basic bio-medical problems that remain unresolved. In the past, in studies dealing with the effect of stress factors, particular attention was given to specific organs such as mantle, gills, kidney, digestive gland, gonad etc., but haemolymph was seldom considered as an organ system.

In the present study, two species of clams, *Sunetta scripta* and *Villorita cyprinoides* var. *cochinensis* were used. The haemolymph parameters like total and differential haemocyte counts, total carbohydrate, glycogen, total protein, acid and alkaline phosphatase in different size groups and also when these clams are subjected to abiotic (by employing different concentrations of copper) and biotic (by giving injections of 1 × $10^8$ cells/0.02 ml of *Vibrio alginolyticus*) stress were studied. The levels of lactic acid in the haemolymph in *S. scripta* when subjected to sublethal concentrations of mercury and copper were also studied. The thesis is divided into eight chapters.

In the first chapter, opinions of different workers on the various aspects of bivalve haemolymph and haemocytes and their functional role including the part they play in defense mechanisms are brought together in the form of a review.

In the second chapter, the study of total and differential haemocyte count is included. In copper-dosed *S.scripta* no significant difference in the haemocyte number was observed between the experimentals and controls, whereas the experimentals of *V. cyprinoides* var. *cochinensis* showed significant drop. In *Vibrio*-injected *S. scripta*, a significant increase in the number of haemocytes started at 48 hrs and continued till 96 hrs whereas in *V. cyprinoides* var *cochinensis*, it started at 3 hrs and continued upto 12 hrs. The reasons for this are explained in this chapter.

In the third chapter, study of haemolymph glycogen and total carbohydrate is described. In copper-stressed *V. cyprinoides* var. *cohinensis*, the glycogen level was lower in the experimentals than in the controls whereas the total carbohydrate values were significantly higher in copper-dosed clams than in the controls in both the clam species. In *Vibrio*-injected *S. scripta*, the haemolymph glycogen values were found to be significantly higher at 3 hrs and in *V. cyprinoides* var. *cochinensis* at 24 hrs than the values of untempered controls. In *S. scripta* following *Vibrio-injection*, total carbohydrate showed significantly higher values upto 12 hrs whereas *V. cyprinoides* var. *cochinensis* showed higher values than the controls at all the time periods. The possible reasons and the probable mechanisms operating are explained to interpret the observed hyperglycemia in the haemolymph when the clams are under abiotic and biotic stresses.

In the fourth chapter, study of haemolymph protein is presented. In *S. scripted* and *V. cyprinoides* var. *cochinensis*, the pattern of protein values shown by the copper-dosed clams was different depending on the concentration of copper employed. From the results, it is evident that the protein values in the haemolymph compartment in copper-dosed condition is a matter of balance between entry and exit of protein into and out of the haemolymph compartment. *Vibrio*-injected ones of both the species of clams did not show any significant difference in protein values when compared with the controls. This is discussed in this chapter.

In the fifth chapter, study of haemolymph acid phosphatase is reported. In copper-dosed experiments with *S. scripta* and *V. cyprinoides* var. *cochinensis*, the results indicated that in synthesis, its release into the haemolymph compartment and its final loss. In *S. scripta*, the *Vibrio*-injected ones showed significantly higher acid phosphatase activity from 3 hrs upto 24 hrs whereas *Vibrio*-injected *V. cyprinoides* var. *cochinensis* showed higher acid phosphatase activity from 3 hrs upto 12 hrs. This is interpreted as the release of this enzyme from the lysosomes in response to the biotic challenge.

In the sixth chapter, study of haemolymph alkaline phsphatase is presented. Copper-dosed *S. scripta* showed significantly higher haemolymph alkaline phosphatase activity whereas copperdosed *V. cyuprinoides* var. *cochinensis* showed no significant difference. In *S. scripta* and *V. cyprinoides* var. *cochinensis*, *Vibrio*-injected clams showed significantly higher activity at 72 and 96 hrs and 72, 96 and 120 hrs respectively. The probable reasons are discussed in this chapter.

In the seventh chapter, study of haemolymph lactic acid in *S. scripta* is presented with emphasis on two aspects: (a) whether lactic acid could be one of the end products if not the major one in bivalves under environmental hypoxic conditions prevailing within the shell and (b) whether haemolymph could be taken as an organ system in studies related to end product accumulation in specific tissues of bivalves. For both, the answer is positive and the reason for this conclusion are discussed in this chapter.

The eighth chapter formed the summary of the thesis.

## M.S.96. SYED ISMAIL KOYA, M.S.–Ecobiology of helminth parasites of finfishes and shellfishes of cochin waters with special reference to digenetic trematodes–1988–

## Dr. A. Mohandas

Among the parasites that infect finfishes and shellfishes, helminths form a major group. They cause mechanical injury, introduce toxic metabolic by-products, deprive the fish of food, act as carriers of other pathogens, and provide a point of entry for other pathogens through mechanical damage. Serious damage to the reproductive organs might cause their partial or total castration. Other economic effects of infection include reduction in the number of food fishes available to fishery, stunted growth, weight loss, decrease in the yield of fish products and rejection of abnormal or diseased fish by consumers leading to subsequent loss of interest in fishery products. Fish transmitted helminth parasites acquired by man through eating raw fish or inadequately treated fish products containing infective larvae or juveniles are well known in parasitology and medicine as helminth zoonoses. Evidently, marine and brackish water fishes exhibit an intricate link in the food chain, and hence the study of helminths of marine fishes, and brackishwater fishes is of paramount significance, so also their larval forms.

**Summary:-** A detailed description of the study area is given. The hydrological parameters, and their impact on the occurrance of helmints are discussed. The prevalence of infection with helminth parasites was found to be significantly high. Taking into consideration of single and multiple infections in different combinations, 540 out of 1934 fishes of 30 species were infected. More young fishes were infected than old ones but old fishes harboured more number of parasites. More females were infected than males, and more carnivores and omnivores were infected than herbivores. The maximum prevalence of infection occurred in the premonsoon season and minimum in the monsoon season. A strict host specificity was recorded in the majority trematodes. Thirty species of digenetic tematodes were collected from 30 host species, and they were identified. Nine species have been treated as new to science. The trematodes belonged to nine families. Four genera, and their hosts are new records from India. Eighteen species of trematodes are from new host species. The entire life cycle of *Philophthalmus (Philophthalmus) cochinensis* sp. nov. was worked out in the laboratory using domestic chicken as the experimental host. Survival characteristics of a curious transversotrematid cercaria, *Cercaria chackai* revealed that it is freshwater form showing considerable tolerence to salinity fluctuations, although the family Transversotrematidae is considered to have a marine origin. The family is restricted to the Indo-Pacific region, and interestingly the members of this family, only seven species, occupy an ectoparasitic niche. *Cercaria melanocrucifera* is described in detail and its pathogenicity in the digestive gland of *Turritella attenuata* discussed. The report on the occurrence metacercarial cysts of *Carneophallus* sp. in prawns, *Metapenaeus monoceros* is the first from Indian waters revealing the role of prawns as second intermediate host in the life cycle of a trematode. This species has public health importance becasue continuous consumption of raw, naturally infected shrimps (infection rate-27.4%), or semi-cooked ones favours the adverse involvement of the heart, spinal cord, and other vital organs. An adult digenetic trematode recovered from the gonad of a female *Perna viridis* was described and is identified as a species of the genus *Gorgoderina*, normally found in the urinary bladder of amphibians and toleost fishes. Occurrence of adult trematodes in invertebrates is rare and this information has evolutionary significance as far as digenetic trematodes are concerned.

## M.S.97. PRABHUDEVA, K.N.–Toxicity Accumulation and Depuration of Heavy Metals in the Brown Mussel Perna Indica–1988–Dr. N.R. Menon

A study on the combined toxicity of copper and silver and the different salt forms of these metals on life and activity of *Perna indica*, the commercially important marine bivalve was carried out.

Acute toxicity of copper and silver; accumulation and depuration of copper in the tissues like mantle, gill, adductor muscle and remaining tissue of *Perna indica;* accumulation and depuration of silver supplied as carbonate and oxide, copper provided in the nitrate and chloride form, from the whole tissue; oxygen consumption during the process of accumulation and depuration; rate of filtration during the process of accumulation and depuration; the rate of accumulation and depuration of copper and silver supplied in nitrate and sulphate form, individually and in combination, and rates of oxygen consumption and filtration during the accumulative and depurative processes when *Perna indica* was exposed to sublethal concentrations of the above metals.

At lethal levels silver was more toxic than copper among the two heavy metals. The results on combined toxicity showed that a combination of copper and silver when supplied in sulphate form was more toxic than the other salt form. At lethal levels these combinations were more than additive with reference to combined toxicity.

The rate of oxygen consumption and filtration were significantly effected by the presence of heavy metals in combination, although the additivity ranged from simple additivity to less than additivity.

The different forms of metals also affected the rate of filtration and oxygen consumption of *Perna indica.* Sublethal levels of copper and silver present in the form of sulphates showed more deleterious effects on oxygen consumption and rate of filtration.

Conspicuous variations were noticed in the rate of filtration and oxygen consumption by *Perna indica* when exposed to heavy metal combinations as a function of time ranging from 0 to 7 days.

The rate at which *Perna indica* accumulated or depurated copper and silver varied as a function of concentration and time. Further, the different salt forms of the same metal were found to influence the rate of accumulation and depuration in *Perna indica.*

The assessment of the load of heavy metals supplied individually, in combination and in different salt forms, showed varying pattern of distribution in the different tissues of *Perna indica.*

## M.S.98. PHILIP SAMUEL, P.–Biochemical Genetics of selected commercially important penaeid prawns–1988

## –Dr. M.J. George

In order to increase productivity of economically important animals, genic manipulation techniques like selective breeding, preservation of genic variation, inbreeding and crossbreeding, hybridization and genetic engineering are followed.

Genetic characteristics of following species were studied. *Penaeus indicus* from Cochin, Tuticorin, Madras and Waltair, *Parapenaeopsis stylifera* from Bombay and Cochin, *Penaeus japonicus, P. canaliculatus* and *P. latisulcatus* from Madras, *P. penicillatus* and *P. merguiensis* from Puri and *Metapenaeus affinis, M. kutchensis, M. monoceros, M. brevicornis, Parapenaeopsis sculptillis,* and *P. hardwickii* from various locations in Bombay.

Eleven morphometric variables in 2 species *P. indicus* and *P. stylifera* were measured. Zone electrophoresis method using polyacrylamide gel was employed for separating various enzymatic proteins. Staining of different enzymes was done by histochemical staining methods.

Electrophoretic separation of following enzymes were done:– Acid phosphatase, Alcohol dehydrogenase, Aldehyde oxidase, Aldolase, Alkaline phosphatase, Esterase, General Protease, $\alpha$-Glycerophosphate dehydrogenase, Lactate dehydrogenase, Malate dehydrogenase, Octanol dehydrogenase, 6 Phosphogluconate dehydrogenase, Pyrroline dehydrogenase, Sorbitol dehydrogenase and Tetrazolium oxidase.

In *P. indicus* allele frequency for different enzymes were found out for the samples follected from Cochin, Tuticorin, Madras and Waltair.

For *P. stylifera* gene frequency of different enzymas were also found out.

Tissue expression of different enzymes of 3 different organs namely Eye, Hepatopancreas, and Muscle were found out. After the allele frequency, estimation of heterozygosity of observed and expected was found out. Genetic indentity and distance of the two species was also calculated.

In order to study the ontogeny in the species *P. indicus* some of the larval stages namely protozoea, mysis and postlarva were studied for electrophoresis. Enzymes like Acid phosphatase and Aldehyde oxidase were separated from these samples.

The juvenile stage of *P. indicus* of different size range of 30 mm, 80 mm, and 100 mm were tried for enzymes like Acid phosphatase, Aldehyde oxidase, Octanol dehydrogenase, Esterase, Alcohol dehydrogenase and Malate dehydrogenase. The patterns found in each stages were compared and discussed.

Closely aligned species like *P. japonicus, P. canaliculatus* and *P. latisulcatus* were analysed for general protein variation in different tissues. The difference in protein pattern was found out between *P. penicillatus and P. merguiensis.* Electrophoretic protein separation was carried out in species like *Metapenaeus affinis, M. Kutchensis, M. monoceros* and *M. bervicornis* to demarcate their identity. Besides these protein pattern variation of *Parapenaeopsis stylifera, P. hardwickii* and *P. sculptilis* was also done.

## M.S.99 RAJAN, C.K.–Studies on some characteristics of Indian Rainfall–1988–Dr. R. Anantha Krishnan and Dr. K.G. Nair.

The study has shown near normal distribution of rainfall series at most Indian stations during the annual/southwest monsoon season. The association between cumulated percentage rain amount (x) and cumulated percentage number of years (y) can be presented empirically by an equation, X = y exp (y-100)b involving only one constant for stations having large amounts of annual/seasonal rainfall and small values of co-efficient of variation (C.V.). Similarly, stations with smaller rainfall and higher C.V. values can be represented by an equation, x=ay exp by c, with three empirical constants.

When monthly rainfall is considered, a single normalised curve gives a reasonably good representation of the association between x and y, applicable for long period rainfall data of all Indaian stations. This curve can be used as a useful tool to draw conclusions of hydrological interest at any place.

During southwest monsoon season, stations in the Arabian Sea Islands and on west coast of Indian receive their maximum rain amount during early morning/late night hours and minium during noon. For interior stations, the corresponding periods are evening and morning hours respectively. During pre-monsoon season, coastal and inland stations receive their maximum during evening/night hours and minium during noon hours. Retreating monsoon season shows maximum rain in evening hours in west coast stations, forenoon hours in island stations and early morning hours at east coast stations. Minium is received by west coast stations during noon, island stations around evening and inland east coast stations during forenoon.

West coast and island stations show negligible change in diurnal variation of rain intensity during southwest monsoon. Pre and retreating monsoon seasons show significant diurnal variation of rain intensity at all stations.

During southwest monsoon season, stations in the west coast and Arabian Sea islands receive 50% of rain amout in 20 to 25% of the integrated rain duration. The other two seasons show that same percentage of rain amount is received in 12 to 15% of the total duration.

Time of commencement of rain spells shows that during south-west monsoon season, maximum frequency occurs during early morning hours and minimum during noon hours at island and west coast stations. The corresponding periods at the inland and east coast stations are evening and forenoon hours. It has been noticed that during pre-monsoon period, with increasing latitude, there is lag in time of commencement of maximum frequency of spells for the stations from Minicoy to Manglore. During retreatig monsoon, maximum frequency of spells is in evening hours at west coast stations, in forenoon at Minicoy and during early morning hours at inland stations.

70% to 80% of rain spells received at South Indian stations during southwest monsoon, have continued for ≤ 1/2 hr, providing 20 to 35% of season's rain amount. 8 to 10% continue more than 2 hours, providing 40 to 45% of rain amount. Spells which continue for more than 10 hours can occur one each at Trivandrum and Cochin, 3 at Kozhikode 2 at Manglore. 85 to 90% of spells have got rain amounts 1 cm. providing 40 to 50% of season's total. On an average, this season provides a spell each with amounts > 10 cm at Cochin, Kozhikode and Mangalore. During pre-monsoon, 60 to 65% of spells last for ≤ 1/2 hour, contributing 20 to 25% of season's rain amount. Spells with rain amounts ≤ 1 cm are about 75% at most of the stations.

Studies on minute intesity of rain spells at Cochin show that west coast stations can have very high intensity, a short duration rain independently or embedded within a long duration spell, having intensities grater than 10 cm/hr.

The behaviour and frequency of occurrence of rain squalls show that about 69% of rain squalls during southwest monsoon season occurs in June-July. Almost all rain squalls are accompained by a freshening of the wind. The direction of wind the time of a rainsquall is northwesterly or westerly.

### M.S.100. RAJENDRAN, C.P.–Systematic Stratigraphic Studies of Cenozoic Sediments of Kerala with Special Reference to Warkalli and Quilon Formations–1988–Dr. K. Soman.

The Kerala region is marked by a sedimentary basin which is one in the chain of coastal basins along the western margin of India. The marine incursions that occurred in the Mesozoic and the Cenozoic, have a bearing on the depositonal facies of the western coastal basins of India. The knowledge hitherto gathered with regard to the distribution of the sediments in the Kerala basin in space and time has been much limited. This has restricted a proper assessment of the evolution of this sedimentary basin and interrelationship of various facies. New evidences on the age and the stratigraphy of these sediments necessitate a re-examination of the stratigraphic evolution of the Kerala sedimentary basin. The geological sections comprise variegated sandstones and kaolititic clays with lignitic seams and isolated occurrences of limestone around Quilon. In the peripheral parts of the basin in the east, a sequence of ferruginous gritty sandstone could be traced. Laterites have been observed under the basal ferruginous sandstones at several places in Kerala. Apart from the scattered outcrops, thick sub-surface sections of sediments (more than 600 metres) have been recorded in the coastal plain around Alleppey (9°23'50"). The litho-units recorded in the outcrops extend and attain the maximum development in this area and extend further into the offshore area. Ferruginous gritty sandstones, traced in various locations in the peripheral parts of basin are coarse, gritty and well indurated and comprise angular to subangular grains of quartz in a hematitic matrix. The deposition of these sandstones occurred in a warm oxidising environment possibly during Late Cretaceous-Early Tertiary times. Laterite zones underlying these ferruginous sandstones with prediminance of gibosite in this laterite suggest initiation of desilication or bauxitisation under some favourable conditions. At a later stage, the desilication process stopped and lateritization process was started. Two events of lateritization, the first spell during Late Mesozoic prior to the deposition of sedimentaries and the second spell of lateritization during late Tertiary, developed over the sedimentaries, have been proposed for the Kerala region, on the basis of superposition, mineralogy and palomagnetic data.

The sedimentary basin of the coastal plain is thickest around Alleppey. A thicker blanket of Quaternary deposits in this area has also been noticed. The boundary of Quaternary and Tertiary sediments is marked by a laterite horizon in the sub-surface sections. The top of the Tertiary is marked by a sandstone clay bed alternations followed by a thick zone of clay beds. The clay beds are underlain by a thick zone of coarse peboly sandstones which extend to a depth of 210 metres. Fossiliferous calcareous and carbonaceous clays with intercalations of sandy horizons continue down to a depth of 350 metres. This is followed downward by the carbonaceous clays.

Lenses of limestones and microfossils have been recovered around 470 metres. Below a depth of 560 metres, the sediments consist mainly black shales and clays. The ferruginous sedimentary units occurring above and below the carbonate facies in the western part become a single unit in the eastern part with the absence of carbonate unit in the middle.

Palaeontological studies indicate that the outcrops and upper part of the Quilon Formation (200–270m) in the boreholes belong to the Early Miocene to Middle Miocese period. The Oligocene sequence (290 metres to 350 metres) is marked by characteristic planktonic foraminifera. Eocene (454 metres to 494 metres) is marked by the larger foraminifera in the lower part of the subsurface sections apart from Oligocene and Miocene markers in the overlying sediments.

Based on the evidences, it is proposed that during a regressive phase of the sea, possibly in the Late Miocene, the sediments including lignitic pieces and fossils were eroded and redeposited in the coastal area and that the overlap

Data obtained from the experiments were statistically analysed, following standard procedures to ascertain if there were any significant influence of the test parameters on the growth of the bacteria. The optimum requirements for pH, selected vitamins and trace elements for maximum growth of the 9 strains have also been found out.

Relevant literature on the research topic have been reviewed in the Introduction section of the thesis.

## M.S.104. SAJAN, K.–Studies of the Mineralogy Geochemistry and Origin of the Modern sediments of the Ashtamudy Lake, Kerala – 1989–Dr. K.T. Damodaran

The Ashtamudy Lake, which is infact an estuary is the 2nd largest estuary in Kerala, lies between Lat. 8°55' N to 9°N and Long. 76°33' E to 76°37' E. The surfacial sediments of the lake were studied for their mineralogy, geochemistry and their upon the origin. The whole work is laid out is 6 chapters.

For the better understanding and expression of the results of the analyses, the lake has been divided into 3 zones namely the eastern central and western parts.

Besides to the mineralogy and geochemistry of the sediments a textural analysis was accomplished to confer a nomenclature to the lake sediments and then to obtain the general sedimentary framework. The study also enfolds the environment of deposition and the lateral variation in texture and mineralogy. The heavy and clay mineral investigations enabled us to decipher the nature, texture, and source of sediments; organic matter and carbonate contents and the geochemical analysis of major and minor elements helped to establish the distribution and concentration of the same in regard to the various physicochemical processes operating in the lake. Study of trace elements holds prime importance in this work since their concentration can be used to outline the extent of contaminated bottom area, as well as the source and dispersal paths of the discharged pollutants. This study could bring out a vivid picture of the mineralogy and geochemistry of the lake sediments in different environments viz. fresh water, brackish water and marine environments that are confined to the eastern, central and western parts of the lake respectively.

From the general sedimentary frame work, it is observed a general decrease in grain size from eastern to central part and then an increase towards the western part. The organic matter content is high at eastern and central parts where as at the western part it is low. The direct relationship between the texture of the sediment and the organic matter content is brought out here. Also the role of texture and organic matter content to demarkate the zones of different energy level in the lake. From the carbonate content and its distribution, it is concluded that carbonates are of biogenic in origin.

The variations in the mineralogy of the heavy, light and clay minerals directly reflects the variation in their respective sources. The progressive depletion of feldspars and corresponding enrichment of quartz from the eastern through central to western part ,is attribured to selective abrasion and chemical weathering The dual source of sediments to the lake is also broughtout from the mineralogical studies.

The results of the geochemical analysis for the bulk sediments and clay fractions shown that most of the elements are concentrated in finer fractions and the variation in their content is mainly due to the different geochemical environment in the lake.

For monitoring the pollution aspects of the lake sediments, the values obtained for the trace elements were compared with values obtained for the unpolluted sediments of the other lakes. It is found that the anthropogenic disturbance is high and the sediment is polluted with Cu, Ni, Cr, Zn, Pb and As, but unpolluted with Co.

The importance of the study is that the variations in texture, mineralogy and geochemistry of the sediments could delineate the sediments of different environments.

## M.S.105. JOSE P. JACOB–Combined Toxic Effects of Oil and Pesticides on Selected Marine Invertebrates–1989– Dr. N.R. Menon

Among the various pollutants identified as hazardous to aquatic life, oil and Pesticides rank greater importance. Although, Pesticides are note directly introduced into the sea or estuaries, it is proved that they are toxic to non-target aquatic organism. On the other hand, Petroleum hydrocarbons are known to affect the health of the aquatic ecosystem in general and intertidal animals in particular. Therefore, documentation of the effects of Pesticides and Petroleum hydrocarbons on the life and activity of aquatic animal is of cardinal importance. Basic studies are necessary for the refinement of methodologies. Further, documentation on the stress profiles marine animals subjected to sublethal exposure to Oil and Pesticides will become highly essential to understand the impacts of these on the coastal ecosystem.

In the present investigation two species of Mulluscs, namely *Villorita cyprinoides* var. *cochinesis* a common representative of the oligo and mesohaline stretches of the Cochin backwaters and *Perna indica* the brown mussel, extensively distributed along the intertidal and subtidal rocky beaches of the South West coast of India, were selected to analyse the toxic effects of Oil and Pesticides. The toxicants employed were two organochlorines, DDT and Aldrex and two organophosphates Ekalux and Dimecron and water accommodated fractions of Light Diesel Oil-LDO (WAF)-and Persian Gulf Crude-P.G. Crude (WAF). These were employed either singly or in combinations.

In general, information on the toxic effects of Oil and Pesticides on marine and estuarine bivalves are detailed out in the Review of Literature, In this chapter, available papers on acture and subacute toxicity organochlorines and organophosphates, crude and refined oil are critically reviewed. Most papers which explain the various causative factors that govern the sublethal toxicity of Pesticides and Oil are also documented. Information available on combined toxicity of Pesticides and Oil although limited is also provided.

The chapter on Material and Methods details out the animals used for the present study, the areas and methods of collection. Instrumentation employed, chemical methods followed and experimental design to study the lethal toxicity, oxygen consumption filtration, byssogenesis, accumulation and depuration of Petroleum hydrocarbons are given. The statistical techniques used for analyses and computation of data also outlined in this chapter.

was not consistent and significant in the remaining species.

Studies on the effect of freezing and thawing on enzyme activity in press juice of fish muscles have shown that the substantial increase in the activity of lipoamide reductase can be employed in distinguishing fresh fish from that which has been frozen and thawed.

Prolonged cold storage (–20°C) of fish and shellfish resulted in a steady decrease in the activities of the enzymes $Ca^{2+}$ ATPase and lactate dehydrogenase. Significant correlations were observed between fall in enzyme activity and other biochemical and sensory tests for freshness. Based on these results critical values of enzyme activities were determined. In the case of fish muscle $Ca^{2+}$ ATPase, limiting value was in the range of 0.011–0.088 $\mu$ mole Pi/min/mg protein and that of LDH activity ranged from 174.1 to 204.3 NADH $\mu$ mole/min/mg protein. These results indicate that activities of the above two enzymes can be used as indices of freshness of fish and shellfish subjected to frozen storage (–20°C).

A study was conducted on cold shock reactions in several species of freshwater, brackish water and marine species of fish. When compared to storage at room temperature, chilling resulted in rapid onset of stiffening in the various species studied. A comparative study on the bio-chemical characteristics of cold shock reactions at 0°C and rigor mortis at room temperature was carried out to find out the subtle differences between the two phenomena. A definite lowering in muscle PH was found associated with stiffening at 0°C. Muscle glycogen content also decreased similarly. ATPase activity in fish muscle was determined to find out the extent of denaturation of myofibrillar proteins. Although ATPase activity at the time of onset of stiffening at 0°C was higher than activity at the time of death, it was found lower than in fish muscle undergoing rigor at room temperature. Studies on the effect of exposure to different temperatures on the onset of stiffening in tropical fishes have shown an intense thermal shock in fishes exposed to 37°C.

## M.S.103. ARUN SHIVNATH NINAWE–Studies on Certain Nitrogen Cycle Bacteria in the Prawn Culture Fields of Kerala–1988–Dr. R. Paul Raj.

In the South-West Coast of India an extensive type of prawn culture operation is being practised in certain paddy fields, known as "Pokkali fields" found in the vicinity of Cochin Backwaters, and high rates of prawn yield have been reported from this culture system without any artificial nutrients enrichment or supplemental feeding. The high natural productivity of these fields may be the probable reason for such high yields. The productivity of these brackish water ponds, however, depends to a greater extent on the physico-chemical properties of water and sediments, particularly the availability of nutrients, such as nitrogen and phosphorus. Moreover, marked changes in the salinity of the water occurring during the different seasons are likely to bring about profound influence on the bacteria associated with the biogeochemical transformation of nutrients. However, there has not been any concerted attempt to study the bacteria involved in the turnover of nutrients in these prawn culture systems. The present investigation was undertaken to study the ecology of certain groups of bacteria involved in the nitrogen cycle in selected perennial and seasonal prawn culture fields.

The investigation was carried out during 1982–1985, at Narakkal (76° 14'E longitude and 10°0.3'N latitude), a fishing hamlet in the Vypeen Island, about 15 km North-West of Cochin on the South-West Coast of India. Four ponds were selected for the study: two of which are perennial prawn culture systems located within the premises of the prawn culture laboratory of the Central Marine Fisheries Research Institute, and the other two are seasonal prawn culture fields, where prawns and paddy are cultivated during the intermonsoon (October to May ) and monsoon periods (June-September) respectively.

Water and sediment samples were collected fortnightly from four fixed sites from each pond for enumeration of the nitrogen cycle bacteria and for monitoring the environmental parameters. Sampels collected from the four sites of the same pond were pooled, throughly mixed, and representative sampels were taken. Water samples for bacteriological studies were collected aseptically in sterilized BOD bottles of 300 ml capacity. Sediment samples were collected with a impact corer (100 cm x 4 cm diameter) made of perspex material. Sediment from the upper layer of 10 cm was aseptically removed with a sterile spatula and collected in sterilized glass bottles.

Enumeration of bacterial groups involved in the nitrogen cycle, such as aerobic total heterotrophs, proteolytic, ammonifying, nitrifying (ammonia-oxidzers), denitrifying and nitrogen fixing bacteria, were carried out for two years using standard microbiological methods with a view to studying the seasonal variations in their abundance.

Environmental parameters such as temperature, pH, Eh, salinity, nitrite, nitrate, ammonia, dissolved oxygen, organic carbon, total nitrogen and total phosphorus were regularly monitored from all the ponds to study their effect on the distribution and abundance of the selected bacterial groups in water and sediment.

Studies were also carried out on the *in situ* bacterial nitrogen fixation rate, fortnightly, using micro-kjeldhal method, and the effect of environmental factors on nitrogen fixation was computed.

Data were analysed to find out if there were any differences in the bacterial population and nitrogen fixation rates among the ponds, between the seasons, and also between the water and sediment in each of the ponds.

Linear multiple regression analysis of the data was carried out to determine the influence of the various environmental factors on the distribution of each of the bacterial groups, as well as on the aerobic bacterial nitrogen fixation rates in the water and sediment in the ponds.

Thirty nitrogen fixing *Azotobacter* strains isolated from water and sediments were identified based on their morphological, physiological and biochemical characteristics. Experimental studies were made to elucidate the effect of salinity on the growth and nitrogen fixing ability and thirty isolated strains of *Azotobacter* in the laboratory. The optimum salinity required for maximum growth of each of the strains was determined. Effect of incubation time on nitrogen fixing ability of the thirty strains of *Azotobacter* was also studied by sampling on the 15th, 30th and 45th days of incubation.

Experimental studies were also carried out on nine selected *Azotobacter* strains (*Axotobacter chroococcum*- 3 strains; *A. vinelandii* - 3 strains; *A. beijerinckia* to evaluate the effect of pH, certain vitamins (cyanocobalamine, biotin, ascorbic acid and thiamine) and trace elements (cobalt -$CoCl_26H_2O$; copper - $CuSO_4$ $5H_2O$;zinc-$ZnSO_4$ $7H_20$ and iron-$FeCl_3$) on the growth of the strains.

Data obtained from the experiments were statistically analysed, following standard procedures to ascertain if there were any significant influence of the test parameters on the growth of the bacteria. The optimum requirements for pH, selected vitamins and trace elements for maximum growth of the 9 strains have also been found out.

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In the present investigation two species of Mulluscs namely Villorita cyprinoides var. *cochinesis* a common representative of the oligo and mesohaline stretches of the Cochin backwaters and *Perna indica* the brown mussel, extensively distributed along the intertidal and subtidal rocky beaches of the South West coast of India, were selected to analyse the toxic effects of Oil and Pesticides. The toxicants employed were two organochlorines, DDT and Aldrex and two organophosphates Ekalux and Dimecron and water accommodated fractions of Light Diesel Oil-LDO (WAF)-and Persian Gulf Crude-P.G. Crude (WAF). These were employed either singly or in combinations

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The chapter on results presents information on lethal toxicity of the various pollutants on *Perna indica* and *Villorita cyprinoides* either exposed in a fashion, where the toxicants were supplied individually or in combination. The sublethal toxicity of the same animals has also been delineated. Analyses of the tissue load of Petroleum hydrocarbons in the case of *Perna indica* has also been worked out.

Among the four Pesticides used, Ekalux was highly toxic to *Perna indica*, while the water accommodated fraction of Persian Gulf Crude did not produce any lethal effect at the concentrations employed. Whereas, in the case of *Villorita cyprinoides* var. *cochinenses*, Ekalux only, produced toxic effects at low concentrations.

The combination of Pesticides with varying or unvarying concentrations of LDO (WAF) brought down the 96 h LC 50 values of the various Pesticides.

The rate of filtration was found to be highly influenced by the presence of Pesticides and Oil fractions. The combinations of these Pesticides and Oil were found to reduce the effective concentrations of both organochlorines and organophosphates and LDO (WAF).

The reaction of the animals, assessed based on oxygen consumption has also been worked out. The approach of this study was exposure of the animals to sublethal concentrations of the organochlorines and organophosphates and water accommodated fractions of Petroleum hydrocarbons. The effective concentration of individual toxicants when employed singly or in combination has also been elucidated. The presence of Pesticides distinctly influenced the effective concentrations rates of WAF's to bring about variations in oxygen consumption.

Continued exposure to very low concentrations of various Pesticides at times did not bring about any drastic reduction in oxygen consumption. As a matter of fact, at a few instances it resulted in enhanced oxygen consumption in the case of *Perna indica*.

Byssogenesis has been proved to be an extremely dependable index to analyse sublethal toxicity of Pesticides and Oil.

*Perna indica* was found to accumulate large quantities of Petroleum hydrocarbons when they were exposed to low concentrations of Oil fractions for longer duration. The rate of depuration was found to be slow after seven days exposure in raw sea water.

### M.S.106. MATHEW, P.T.–Purification and Characterization of Glucose 6–Phosphate Dehydrogenase in Fish–1989–

**Dr. K. Gopakumar.**

The thesis concerned with a detailed study of a purification characterization and immobilization of glucose 6–phosphate dehydrogenase in pearl spot. *(Etroplus suratensis)* Studies on carbohydrate metabolism is very important in plants, animals and other living organisms. Tricarboxylic acid cycle or kreb's cycle is the most important sequence of reactions by which glucose is metabilized. Hexose monophosphate shunt is a sequence of reaction, other than tricarboxylic acid cycle, by which carbohydrateis metabilized in biological systems including plants and microorganisms. Glucose 6–phosphate dehydrogenase is the key regulatory enzyme in thios pathway. One of the main function of it is to supply reducing equivalents in the form of NADPH. Hepatic glucose 6–phosphate dehydrogenase has been shown to be under both nutritional and hormonal long term regulation.

There are very few reports about the study of hexose monophosphate shunt and glucose 6–phosphate dehydrogenase in fish. Immobilization of enzymes has become very important in recent times. Various materials has been tried for immobilizing glucose 6–phosphate dehydrogenase from fish. Fishes, *Etroplus suratensis* (pearl spot), *Otolithus argentneus* (Tigertooth croacker) *Tilapia mossambica* (Tilapia), *Labeo rohita* (Rohu). *Catla catla* (Catla), *Mugil cephalus* (Mullet), *Sciaena aneus* (Bigeye croaker), *Chanos chanos* (Milk fish) and *Meretrix casta* (Back water clam) were analysed for the glucose 6–phosphate dehydrogenase activity. Muscle, liver and intestine were separately examined for glucose 6–phosphate dehydrogenase activity. It was observed that glucose 6–phosphate dehydrogenase activity was present in the liver of pearl spot to a significant level.

Liver of mature fresh pearl spot was used in the purification of the enzyme. It was homogenized in the buffer at pH 7.0 and proteins were precipitated using ammonium sulphate. Precipitated proteins were made free of ions by gel filtration on Sephadex G–25. It was further purified by ion exchange chromatography on DEAE cellulose in a gradient elution method. Proteins thus obtained were subjected to gel filtration on Sephadex G–100. Purified homogeneous active enzyme protein was obtained. 141 fold purification was effected by the above method.

Homogenity of enzyme was verified by gel filtraion on sephacryl S–200. It was further confirmed by poly-acrylamide gel electrophoresis. Absorption spectrum of purified glucose 6–phosphate dehydrogenase was also found out. Ratio of absorption at 280 nm to 260 nm was 1.71.

Subunit molecular weight of purified glucose 6–phosphate dehydrogenase was determined using sodium-dodecylsulphate polyacrylamide gel electrophoresis. It was found as 60,000. No activity was observed with the glucose 6–phosphate dehydrogenase protein separated on SDS polyacrylamide gel electrophoresis. So monomer was found to be an inactive form. Subunit molecular weight was similar to that of other glucose 6–phosphate dehydrogenase purified from other sources. Molecular weight of purified glucose 6–phosphate dehydrogenase from liver of pearl spot was further determined by gel filtration on sephadex G–100 as 118,000. Investigations showed that nature protein was a dimer of two subunits. So it was proved that active form of glucose 6–phosphate dehydrogenase purified from pearl spot was a dimer.

Amino acid composition of purified glucose 6–phosphate dehydrogenase was determined. Amino acid pattern of the enzyme was similar to that 6–phosphate dehydrogenase isolated from other sources.

Thermal stability studies and pH stability studies were also carried out. pH optimum was found to be pH 8.0. Glucose 6–phosphate dehydrogenase was having maximum activity in Tris HCl buffer. Enzyme was stable between the pH 6.5 to 8.5. It was stable between the temperatures 20°C to 50°C.

Glucose 6–phosphate dehydrogenase purified from pearl spot was specific for the substrate glucose 6–phosphate and coenzyme NADP. It was found to be an NADP specific enzyme. Lineweaver–Burk plots were also drawn. Km values were 105 uM and 50 uM with respect to glucose 6–phosphate and NADP respectively.

The enzyme was inhibited by the product of reaction, NADPH, as in the case of other glucose 6–phosphate dehydrogenases. Further investigations showed that palmitoyl coenzyme A was also a potent inhibitor of glucose 6–phosphate dehydrogenase. It was inhibited in a noncompetitive manner. ATP, ADP and AMP had no effect on the activity of the enzyme. P. chloromercuri benzoate was also proved to be a potent inhibitor of the enzyme.

Glucose 6–phosphate dehydrogenase was activated by $Mg^{++}$ But it was proved to be not an essential requirement for enzyme activity. $Cu^{++}$, $Zn^{++}$, Hg $^{++}$ and $Fe^{+++}$ inhibited the activity of the enzyme. Inhibition and activation of enzyme by anions were also investigated.

The advantage of using immobilized enzymes is that, enzyme activity can be stopped at any desired time by simply separating the solution. Immobilized enzymes give better stability, reusability, improved product recovery and accelerated reaction rates. Various materials have been tried for immobilizing glucose 6–phosphate dehydrogenase. Investigations showed that the chitosan, a byproduct isolated from prawn shell waste is an immobilize of glucose 6–phosphate dehydrogenase purified from pearl spot. Prawn shell as was an excellent source of chitosan. Properties of immobilized enzyme were also studied. Immobilized enzyme could be stored well for five months without any loss of its activity. Shelf life was more than that of nature enzyme. The study brings out a novel application of an industrial waste byproduct chitosan in enzyme chemistry.

## M.S.107. ANIRUDHAN, T.S.–Studies on the Nutrient Chemistry of a Tropical Estuary–1989–Dr. P.N.K. Nambissan.

Studies on the various aspects physiochemical parameters of the estuarine enviornment have received considerable attention in recent years. Such studies help in assessing the quality of water and also provide information on various biogeochemical processes taking place within the estuaries. Estuaries are complex systems, receiving chemical inputs from a variety of sources and the bizzarre variations in the concentration of nutrients during estuarine mixing is addressed as an interesting problem of aquatic chemistry. The behaviour, concentration and distribution of nutrients in estuaries are influenced by numerous factors. Sewage and industrial affluents are knwon to be the prime external sources of nutrients. Under favourable conditions sediment too acts as a reservoir of nutrients and plays a significant part in regulating the nutrient concentration of overlying waters.

The behaviour of nutrients during estuarine mixing may vary from one estuary to another, and even within one estuary it may vary seasonally depending upon the enviornmental conditions such as precipitation, river inflow, biological activity etc. In most estuaries, some of the nutrients may show conservative behaviour while in others these may behave non-conservatively.

The Cochin estuary (09°40'-10°12'N; 76°15'-76°25'E) is a tropical positive estuary on the west coast of India. Like other major estuarine systems the Cochin estuary is also subjected to increasing human impact and is receiving discharges from major industries like Fertilizers And Chemicals Travancore, Travancore Cochin Chemicals, Indian Rare Earths, Cochin Refineries etc. and sewage and storm water through a net work of the large and small canals. Even though there are many refernces in the literature on the hydrographical parameters of the Cochin estuary, not much is known about the nutrient content of these waters, their variations with seasons, inter-relationship and the physicochemical processes that control them. An over all picture of the estuary and its adjacent sea is still largely lacking.

The work incorporated in this thesis deals with the investigations on the temperature, pH, salinity, dissolved oxygen and nutrients of the waters collected at nine stations in the Cochin estuary over a period of one year (1985 - 1986)

Results on the texture and grain size analysis, seasonal and spatial variation of interstitial, adsorbed and total phosphorus of the sediments collected during the period of survey are also incorporated in this thesis.

The thesis is presented in six chapters. Chapter 1 gives an account of the nutrient behaviour in the estuarine enviornment and their characteristics with a brief review of relevent literature. The scope and aim of the present study are also briefly described.

Chapter 2 gives information on the sampling stations and procedures adopted for the collection of water and sediment samples. Physico-chemical and instrumental methods employed by the author for the analysis of the various constituents are described.

Chapter 3 presents the results of the investigations on the hydrographical parameters viz. temperature, pH, salinity and dissolved oxygen. Seasonal and spatial variations of these hydrographical parameters and their inter-relationship are investigated.

Chapter 4 is devoted to the studies on the dissolved nitrogen of the estuary. Variations in the concentration of different forms of nitrogenous nutrients like nitrite, nitrate and ammonia in the waters are described. The salient features of this study are explained on the basis of the general hydrographical conditions, discharge of domestic and industrial effluents. Regressional behaviour between salinity and the nitrogenous constituents and their inter-relationship are evaluated in order to establish the estuarine fate of the above nutrient.

Chapter 5 deals with the results on the various forms of phosphorus like inorganic reactive, dissolved organic, particulate reactive and total reactive phosphorus concentrations both in surface and bottom waters. High levels of some of these constituents are explained on the basis of estuarine mixing, occurence of pollutional discharges from domestic and industrial effluent plants and adsoption/desorption mechanisms between overlying waters and sediments of the estuary. Variation of interstitial, adsorbed and total phosphorus of the sediments are also discussed in relation to the external characteristics and other parametrs like pH, salinity, dissolved oxygen and reactive phosphorus of the overlying waters.

Chapter 6 describes the chemical behaviour of dissolved silicon in the Cochin estuary; the silicon salinity interrelationship is evaluated and presented.

A summary of the present investigations and reference literature are given at the end.

## M.S.108. BENNY N. PETER–Circulation and zonal mass transport in the Indian Ocean region off the Antarctica–1989–Dr. G.S. Sharma

The thesis is a modest attempt to partially enhance the knowledge of circulation of the Indian Ocean region off Antarctica by carrying oceanography of the region. The aim of the thesis is achieved by working out zonal mass transport any by presenting the distribution of properties on isopycnal surfaces and vertical sections.

The estimation of zonal flux following the method introduced by Montgomery and Strop (1962), is a special technique which gives the characteristics of the water flowing in addition to quantitative estimate. The isopycnal analyses selected for studying the circulation has the advantage that the pressure effects are compensated by choosing appropriate pressure levels to determine the density.

Considering the inter-oceanic exchanges, the Indian Ocean is lossing an additional amount of 48.33 Sv into the Pacific Ocean than it gains from the Atlantic Ocean. The zonal eastward flowing Antarctic Circumpolar Current is found to be influenced by bottom topographic features as well as continental boundaries but it does not show significant variation with season. The latitudinal distribution of zonal flux reveals the multistream structure of the Antarctic Circumpolar Current. The core of the current is associated with the Polar Front and major part of the current is taking place north of the Polar Front, compared to the south.

The bivariate distribution of zonal flux denotes that a major part of the flow is taking place in the deeper levels, compared to surface layers. The 50% limit frequencies reveal a considerable contribution of the Circumpolar Deep Water in the Circumpolar Current. In general, the flux is more homogenous in the eastern side compared to the west. The westward flux near the Antarctic coast is prominent in the Weddell Sea while it is not observed in the eastern side.

The southward spreading of the ascending deep water is traced upto the shelf in the central region (20°E to 55°E). The denser Antarctic Bottom Water flow is restricted by the topography of the Mid-Ocean Ridge, though traces of this water are noticed along 20°E and 40°E upto lower latitudes. A little amount of Antarctic Bottom Water is produced in the region off Enderby Land.

Zonal fronts in the Southern Ocean are the important vertical structures that differentiate the water masses. The Subtropical Front is stronger south of Africa than south of Australia. The Antarctic Polar Front is strong in the west and central regions. But in the east, south of Australia, the Subantarctic Front is much stronger. The Antarctic Polar Front is at about 50°S south of Africa while it is further south (at about °S), south of Australia and a slight southward shift is noticed during summer.

The Antarctic Divergence, a transition between the eastwind and westwind drifts, is well developed in the west. A dicothermal layer is present in the west during summer. The eastward arm of the Weddell Sea Cyclonic Gyre is found to terminate somewhere west of 40°E.

More reliable estimates of the Antarctic Circumpolar Current system are essential for constructing numerical models of general ocean circulation. The heat flux from one ocean to another as well as the loss to atmosphere is invariably related to the transport of Circumpolar Current. The improved investigations in the fields of atmosphere-ocean exchanges of momentum, heat and moisture are needed to enrich our understanding of the circulation and heat budget of the Southern Ocean.

## M.S.109. CLARA MARGRET KATTICARAN–Studies on the biology of the clam, sunetta scripta (linne) from the sub-tidal waters of Cochin–1989–Dr. K.Y. Mohamed Salih

The clam *Sunetta scripta* (Linne) is the dominant species of the benthic community of Cochin barmouth area. *S.scripta* has been reported from Madras, but to date there has been no formal report of the species from Cochin, not has there been any attempt to study its biology. *S.scripta* is consumed by the fishing community, but it is in greater demand for the lime content of its thick shells which support flourishing cement industries. The meat which is discarded by these industries can be used as a cheap food source. The demand for shells has led to indiscriminate fishing which together with other environmental stress factors can result in a decimation of the breeding population.

For the past decade bivalve mollusc have come to be recognised as biological monitors of aquatic metal pollution. Heavy metals, rank second only to pesticide and related compounds as potential hazards particularly in estuaries and neritic zones. The clam beds of *S.scripta* at the barmouth are ideally located for the sampling of waters which contain discharges from urban sources, industries and the harbour. The high tolerance capacity for trace metals, copper and mercury, by *S.scripta* as revealed by earlier studies is intriguing. The commercial and scientific importance of this clam, therefore, warrants a detailed investigation of its biology and biochemistry.

The thesis is presented on eight chapters. The first chapter introduces the topic of study and contains a review of similar work done in other bivalves, in the sub-continent as well as abroad.

The second chapter describes the species, its habitat preferences and its distribution in the bar-mouth and adjoining region. Possible reasons for its recent appearance and dominance in the benthos are discussed in the light of environmental perturbances in the bar-mouth.

The third chapter describes gametogenesis in *S.scripta*. The development of the gonads from early stage to maturity is traced and documented. The size of the clam at first maturity is also determined. The development of the gonad is correlated with environmental parameters to discover the effect of a triggering factor.

The fourth chapter deals with the biochemical consitituion of *S.scripta*. Levels of moisture, total protein, total carbohydrate and lipid are estimated in whole male, female and clams of indeterminate sex and separate organs through a period of two years. Calorific values of whole male, female and indeterminate clam tissues was also estimated through the study period. A relationship is established between seasonal changes in biochemical levels and gonadal development in the clam.

The fifth chapter investigates temporal variations in trace metal of *S.scripta*. Ash level of the whole male, female and when available indeterminate clam was estimated. Levels of copper, chromium, nickel, cobalt, manganese and arsenic were determined. Correlations between metals and between sexes were calculated and tested for significance.

The sixth chapter describes a study of the bio-chemical effects of sub-lethal copper toxicity in *S.scripta*. An experiment is described whereby $O_2$ consumption of *S.scripta* and lactic acid accummulation under toxicant induced functional hypoxia is estimated. The experiment was designed to study these factors over seven days of exposure and seven days of consecutive depuration.

The seventh chapter discusses changes in glycogen and total protein under the experimental conditions described above, in the light of the knowledge that lamellibranch molluscs do not generally follow the classic Embeden-Meyerhof pathway of glycolysis under hypoxia.

## M.S.110. HARISH, C.M.–Mass transport in the equatorial Indian Ocean–1989–Dr. G.S. Sharma

Ocean currents play pivotal role in the creation and annihilation of heterogenity in the hydrosphere. The equatorial parts of the oceans which derive maximum energy and also have a higher storage capacity compared to the land mass act as the sources and sinks for the atmospheric circulation which in turn controls the oceanic circulation.

The Indian ocean, particularly the region north of 10°S, is unique in many respects because of its closed boundary in the north; while the other two major oceans are connected both to the north and south polar regions. This uniqueness results in a peculiar nature of the semiannual variation of the atmospheric circulation called the monsoons. Hence even a normal study of the equatorial Indian Ocean is by itself an interesting one, because any numerical model that is to be simulated should satisfy all the conditions particularly the time variability. To a certain extent attempts have been made to study the current system in the equatorial region of the Indian ocean particularly in the western region. But there is very little work that is carried out about the current system south of the equator as a whole, and there is not any serious attempt to study the mass transport in this part of the world oceans, in spite of the fact that it is the mass transport which gives an estimate of the transport of heat energy, but not simply the currents alone. Moreover, the estimates of mass transport, specifically its marked temporal variability induced by the monsoonal wind reversal, serve not only in the validation of the ocean atmosphere coupled models but can also be easily parameterised to be incorporated in the models which would help in turn in further refining them. In the present thesis, in view of the significance of the study of mass transport, it is proposed to study the mass transport covering the area between 50°E and 110°E, and between 5°N and 20°S.

Although the title is mentioned as mass transport in the equatorial Indian ocean, in view of the South Equatorial Countercurrent present between 10°S and 15°S, the study is extended upto 20°S in order to cover the mass transport carried out by the South Equatorial Countercurrent. While computing the mass transport, the method of Montgomery and Strop (1962) is adopted. This technique has a special advantage in that the characteristics of the waters can be delineated. To substantiate further, meridional sections covering the area, wherein the distribution of temperature, salinity, and thermosteric anomaly are also included.

The thesis is divided into six chapters with sections and subsections as given below:

I Section (i): Introduction and description of the study area
  Section (ii): Methodology and choice of data
II Transequatorial vertical sections of temperature

III Transequatorial vertical sections of salinity
IV Transequatorial vertical sections of thermosteric anomaly
V Zonal transports and vertical sections of geostrophic velocity
VI Summary and conclusion.

## M.S.111. SYED AHMAD ALI–Studies on the evaluation of different sources of proteins, carbohydrats and mineral requirements for juvenile penaeid prawn *Penaeus Indicus* H. Milne Edwards–1989–Dr. P. Vedavyasa Rao.

Adequate seed and appropriate feed are the two essential requisites for the culture of prawns. Feed is an important component both in hatchery production of seed and in culturing the prawns in grow-out ponds to marketable size. For preparing balanced and low cost feeds, knowledge on the nutritional requirements of the candidate species and the evaluation of locally available raw materials are essential. In this context, the evaluation of different sources of proteins and carbohydrates and the requirement of minerals in the diet of the prawn *Penaeus indicus*, an important species for culture along the entire Indian coast, has been undertaken in the present study.

The purified proteins albumen (egg), casein, fibrin (blood) and gelatin were evaluated with the objective of finding the most suitable protein source for formulating research diets in nutritional studies. Nine natural protein sources, clam meat, fish meal, mantis shrimp (*Squilla*), prawn waste, silkworm pupa, coconut cake, gingelly cake, ground nut cake and *Spirulina* were evaluated for juvenile *P.indicus* in order to indentify appropriate protein materials for formulating practical feeds. These evaluations were caried out through standard methods of nutritional biochemistry by measuring digestibility, biological value (BV), net protein utilization (NPU), protein efficiency ratio (PER) Food Conversion Ratio (FCR), and growth in statistically designed feeding experiments.

The endogenous nitrogen excretion (metabolic faecal nitrogen), determined for the first time in *P.indicus*, was found to be on an average 324 mg N per 100 gram diet. Among the purified proteins tested, fibrin and albumen had high biological value for *P.indicus* followed by casein. Gelatin was found to be a poor protein source. BV, NPU, and PER were high at low dietary protein level and showed decreasing tendency with the increase in the dietary protein level, while the digestibility of pretein in the diet tended to be low at lower levels and high at higher levels of dietary protein, though the difference was not statistically significant. The requirement of protein in the diet of *P.indicus* was found to be 25% with albumen diets and 29% with casein diets at which the animals showed positive nitrogen balance. Among the natural protein sources, the animal protein materials were significantly superior to the plant proteins sources. They showed higher growth, BV, NPU and PER over plant protein sources, though their digestibility was lower than that of the plant materials. The superiority of the materials are in the order fishmeal, clam meat, prawn waste, and mantis shrimp. Silkworm pupa was found to be a poor protein source. Among the plant proteins sources, the order of superiority was *Spirulina*, ground nut cake, coconut cake and gingelly cake. The diet having 70% animal protein source and 30% plant protein source gave the best growth and food conversion ratio.

In the carbohydrates, three monosaccharides, glucose, fructose, galactose, two disaccharides, maltose, sucrose and two polysaccharides, glycogen, starch were evaluated through their digestibility, growth of prawns and FCR. Only maltose and starch were efficiently utilized by *P.indicus*. All the other carbohydrates tested gave poor results. However, a mixed carbohydrate having sucrose, maltose and starch in equal proportion was found to be the best source of carbohydrate in the diet of prawn. The diet with 22.5% carbohydrate produced the best performance at constant protein (34.8%), while at constant lipid (6%), the dietary carbohydrate showed protein sparing effect. The diet with 6% lipid and 33% carbohydrate gave the best performance. Cellulose was found necessary in the diet of prawn and it could be used upto 10% in the diet for the efficient utilization of the diet.

The requirement of the minerals calcium, phosphorous, copper, zinc, magnesium and manganese in the diet of *P.indicus* was determined. It was found that the prawns required 0.53% of calcium and 1.05% phosphorous in their diet. Best food conversion ratio was obtained with the diet containing 13.6 mg copper and 23.6 mg of Zinc per 100 g diet. While magnesium was not found to be required in the diet, addition of manganese to the diet depressed the growth of prawns.

Using the information obtained on the nutritional requirements of *P.indicus* and also the ingredients evaluated in the present study, a purified diet and a practical feed were formulated. Both were compared to the conventional prawn feed, clam meat, in long term feeding experiments. The purified diet resulted in high survival. The practical feed produced the highest growth and the best FCR superior to that of the conventional feed. The possiblities of using the purified diet in nutritional studies of prawns and the practical feed for the culture of penaeid prawns were discussed.

## M.S.112. KRISHNAKUMAR, P.K.–Physiological Effects of Some Heavy Metals on Perna Viridis (Linnaeus)–1989–Dr.R. Damodaran.

Concern over heavy metal pollution has received greater attention in the recent past. Most of the heavy metals are potentially harmful to most organisms at some level of exposure and absorption. The capacity of bivalve molluscs to accumulate potentially toxic heavy metals in their tissues, far in excess of environmental level is well known and has become the focus of an increasing number of studies. People concerned with environmental management increasingly recognise the need for monitoring physiological and biochemical effects to detect changes in the environmental quality. Mussels are now receiving considerable attention as subject of such pollution studies and have been proposed as suitable indicators for monitoring heavy metal pollution in the marine environment both locally and globaly as in "Mussel watch" programme.

The green mussel *Perna viridis* (Linnaeus) has wide spread distribution along both east and west coast of India. This species is ecologically and economically important, with outstanding potential for use as biological indicator of marine environmental quality. Therefore *P. Viridis* was selected as a test organism and was collected from a pollution free environment. Three toxic heavy metals namely mercury, copper and zinc were selected for the study since they are widely recognised as most common pollutants in the marine environment.

The main objectives of the studies are:

(1) To collect base line information on some of the physiological indices of stresss in *P. viridis* which are necessary for biological effect monitoring; (2) To study the acute and sublethal toxic effect of metals on some of the physiological and biochemical indices of stress; (3) To understand bio-accumulation, distribution and depuration pattern of heavy metals in different body parts of *P. viridis* (4) To assess the suitability of the Indian mussel *P. viridis* as a biological indicator of heavy metal stress, in the marine environment.

The thesis consist of eight chapters, the first chapter is general introduction which covers preface, general literature review and the objectives of the study.

The second chapter deals with the physiology of *P. viridis* and the effect of body size on it. In order to have a base line information of physiology of *P. viridis* $O_2$ uptake, ammonia excretion, O:N ratio, filtration rate and body condition index were studied. Knowledge of a test organism's physiological responses to intrinsic factors is required for the planning, measurements and interpretation of any programme monitoring biological effects of pollution.

The third chapter discusses acute of Cu, Hg, and Zn so as to compare the toxic effects of these metals by determining 96 h LC50 and EC50 values. LC50 values were determined by static bioassay method and the effect of size group on toxicity was determined. EC50s were determined by studying the effect of metals on filtraion rate. Animals of smaller size group were found to be more sensitive to metal toxicity.

The fourth chapter is on bioaccumulation of Cu, Hg, and Zn discusses their bioconcentration factors and rates of accumulation in gill, mantle, viscera and muscle. The effect of salinity and size group on bioaccumulation was studied. The rate of accumulation of these metals were found to be high in smaller animals. Cu and Zn accumulation rates were found to be high in lower salinity.

The fifth chapter is depuration of Cu, Hg, and Zn different body parts after 5,10,15,20 and 25 days of exposure in clean sea water. Initially mussels were exposed 4 days in different concentrations of metals. Rate of depuration was studied in 35% o and 25% salinity ranges and biological half-lives of above metals were determined. Hg was found to be having very high biological half-life.

The sixth chapter deals with long term sublethal toxic effects of Cu on the general physiological indices of stress like respiraton, ammonia excretion, O:N ratio, filtration rate and body condition index. Animals exposed for 20 days in sublethal concentrations of Cu, were used for this study. The above mentioned physiological parameters were found to be useful in assessing sublethal copper stress.

The seventh chapter is on the sublethal toxic effect of Cu, Hg and Zn on respiration and filtration rate. The toxicity of Cu and Hg were compared by studying the effects on respiraton and filtration rate in *P. viridis* after 0,24,48,72 and 96 h exposure. The toxic effect of Hg was more severe on filtration rate than on respiration after 4 days exposure.

The eighth chapter deals with heavy metals stress and carotenoid concentraton in *P. viridis*. Carotenoid located in cytosomes or carotenoxysomes were reported to be taking part in anoxic energy production in molluscs. Mussels exposed to various acute and sublethal toxic levels of Hg, Cu and Zn were analysed to find out the carotenoid concentration in their body. The carotenoid concentration in the body of mussels were found to be acting as a general index of stress.

A summary and list of references are given at the end.

## M.S.113. JOSEPH K.J.–Studies on some aspects of Phytoplankton–1989–Dr. P.V. Ramachandran Nair.

The thesis deals with the results of investigations, on various aspects of algal plankton such as size spectrum of some estuarine and neritic species, floristic composition of planktonic algae in the nearshore waters and temporal and spatial ariation of microplankton, chlorophyll and primary production in the Cochin estuary. Besides, the productivity in a polluted ecosystem and growth characteristics of a few cultivated algal species have also been studied.

The study of floristic size spectrum of the estuarine and inshore algal plankton with their specific contribution to the production in terms of cell numbers, chlorophyll and primary food is a useful tool in the estimation of fishery resources. Since the various size fractions of the algal flora forming the food of different varieties of consumers, many of them being selective feeders, the type of fishery can also be assessed provided the selectivity of diet of the concerned consumers are known.

The planktonic algae in a selected site each in Cochin estuary and inshore waters have been isolated by fractional filtration and classified into four size groups ie. $< 60\,\mu$ (SG.1), 60-75 $\mu$ (SG.2) 76-99 $\mu$ (SG.3) and $> 99\,\mu$ (SG.4). The first size group forms the nanoplankton and the remaining size groups form the microplankters. The estuarine nanoplankters form an annual average of 70.7% of the total floristic composition and they contribute 69.5% of the total chlorophyll *a* and 73.0% of the total organic production. In the inshore waters the nanoplankton contribution in terms of chlorophyll *a* and carbon assimilation is 63.0%. The observed nanoplankton contribution in terms of population density of 14.9% is exclusive of picoplankton and hence is infact an under estimation.

Studied the impact of industrial effluents an bio-productivity near the industrial belt at Alwaye in the tributary of Periyar river and adjacent Cochin estuary. In the control site the primary organic productivity is 2113.2 mgC/m$^3$/day and at the pollution hit area the primary production is reduced to 10%, the productivity potential cut (PPC) being 90%. PPC shows a gradual decreasing trend in the three down stream stations their values being 80%, 75% and 25% respectively depending on the distance from the source of pollution and consequent degree of dilution of pollutants. In the upstream station beyond the impact site the PPC is 80%. Thus the inhibition of organic production at the primary trophic level is due to the stress of industrial effluents on biota caused by ecophysiological factors.

The cultivated species of *Testraselmis gracilis* showed an increase in growth constant with increase of PO$_4$ concentration upto 5 $\mu$g/1 but with higher concentration of phosphate the metabolic activities leading to cell synthesis is not accelerated. The effect of four potentially toxic metal viz. Cu, Hg, Zn and Pb on the growth constant and generation time of the blue green alga *Synechocystis salina* has been studied at two different concentrations of each metal. With 0.05 ppm Cu the cells require more doubling time and 0.10 ppm Cu is foundd to be lethal to the alga. While mercury at both 0.05 ppm and 0.1 ppm concentration is found to inhibit the metabolic processes Pb at both concentrations are found to be lethal to the alga. Zinc is found to prolong the doubling time with the increase of its concentration.

The bioproductivity of Cochin estuarine system at the primary trophic level as a whole being the ordder of 100,000 tonnes annually, can sustain a rich biota inclusive of several penaeid and non-penaeid prawns and estuarine fishes through an intricate food web and still leave surplus of organic matter for recycling. However the study also reveals that the impact of industrial pollutants can inhibit the bioproductivity in restricted areas.

## M.S.114. SUNEELA, S.S.–On the Climatological aspects of Air pollution potential over Trivandrum–1989–Dr. D.V. Viswanadam and Dr. H.S. Ram Mohan.

The study of air pollution potential is essential for any urban area in order to initiate remedial measures for the mitigation of air pollution. The main objective of the study is to provide the climatology of air pollution potential and to give the spatial distribution of sulphurdioxide concentration for Trivandrum. Sulphur dioxide is the single most important contaminant and is very effective even at low concentration.

A detailed study of atmospheric conditions for any urban area is essential since the dispersion and dilution of pollutants emitted into the atmosphere is solely governed by it. The extensive literature survey carried out as a part of the study emphasises the necessity of studying the climatological occurrence of inversions, isothermals, lapse conditions, mixing heights, ventilation coefficients, winds and stability. Since Gaussian model is the most widely used one, It was used for Trivandrum City and the spatial distribution of sulphur dioxide concentrations was studied.

To study the atmospheric pollution potential over Trivandrum, meteorological data for a five year period 1977 to 1981 was made use of. Data of emission inventory for all the factories in Trivandrum was also collected. The mixing height has also been determined for every hour on all days of the five year period according to the method developed by Holzworth (1964). Ventilation coefficients have been computed by multiplying mixing height with wind speed. Upper air temperature structure has been analysed and frequency table of inversions, isothermals and lapse conditions in every 50mb layer of the atmosphere from surface to 500mb level has been prepared. Pasquill stability categories have been determined for every hour for the entire period of study. The diurnal and the monthly variation of these parameters have been also been studied. Wind roses have been drawn on a monthly basis taking the surface wind for a five year period together by classfying them into sixteen direction classes and five speed classes. The climatology of air pollution potential has been studied in detail giving equal importance to each of the parameters involved. Using all the possible parameters such as mixing height, wind speed and atmospheric stability a new pollution potential index is developed and applied for Trivandrum City. By applying Gaussian plume model, the spatial distribution of sulphur dioxide concentrations over the city has been determined and represented diagramatically for each month.

The occurrence of inversions and isothermals over Trivandrum is not in considerable frequency as to cause any adverse effect of pollution. Studies of mixing heights and ventilation coefficients show that these values are negligibly small during night–time compared to daytime. Wind is maximum during southwest monsoon season and is mainly from the northwestern sector. During night–time except in the monsoon season calm conditions comes to about 75%. Studies on atmospheric stability show that stable conditions which have an adverse effect on the dispersal of pollutants are observed only during night–time and unstable conditions during daytime. It is seen that wind direction fluctuation range can be taken as a measure of surface turbulence. Studies on pollution potential index suggest February as the most favourable month for the dispersion of pollutants. The isopleth analysis for studying the spatial distribution of sulphur dioxide concentrations over Trivandrum suggests the northeastern part of the city as the optimum location for further industries.

## M.S.115. Babu, C.A.–Studies on air pollution Meteorology with special reference to Madras City–1989–Dr. D. Viswanadam and Dr. H.S. Ram Mohan

Once a gas emitted into the atmosphere, its dispersion and the subsequent concentration are solely governed by the prevailing meteorological conditions of the region. A knowledge of atmospheric dispersal capacity is essential for developmental activities to keep the pollution level within the tolerable limit.

The main objective of the study is to provide a comprehensive picture of the atmospheric potential for the dispersal of pollutants over Madras City and neighbourhood. This includes spatial distribution of sulphur dioxide concentration due to industrial sources in additon to the establishment of climatology of atmospheric dispersal capacity. The spatial distribution of sulphur dioxide can be determined by means of theoretical models, provided the emission inventory is known in addition to the meteorology of the area.

For this study, hourly temperature and wind data at the surface, three-hourly cloud data, upper air temperature data, wind speed and wind direction fluctuation data for every 15 minutes and air pollution data were analysed. The review of literature reveals that for any urban area the study of inversions, isothermals, lapse conditions, mixing heights, ventilation coefficients, wind roses and atmospheric stability is vital. It also reveals that despite the presence of various mathematical models, Gausian plume model is the widely used on because of its encouraging results and easy adaptability. Keeping this in view fast developing metropolis, Madras situated on the east coast of India, is chose for a comprehensive study of the atmospheric dispersal capacity and the spatial distributioon of sulphur dioxide by means of Gaussian model.

The percent freqeuncy of occcurence of lapse conditions is extremely high in all the months. The hourly values of mixing heights show a clear cut diurnal variation. The diurnal march of mixing height closely follows the diurnal temperature march. The ventilation coefficient also shows a diurnal variation with highest values occurring in the afternoon hours. The most predominant Pasquill's stability class is F. Highly stable conditions during night-time and neutral to unstable conditions during daytime are the important features. The study of wind roses reveals two prominent wind directions in the entire year namely southwesterlies and northeasterlies. In most of the months calm wind prevails during night. The diurnal variation of the wind direction fluctuation range ($\sigma_{o}$:) show near-normal distribution with the maximum around noon. A clear-cut diurnal variation of wind speed fluctuation range ($\sigma_{os}$) is observed in all the months $\sigma_{oD}$ is found to be good measure of surface turbulence. The interrelationships among the parameters show a reasonable representation of $\sigma_{oD}$ for various Pasquill's classes. The mixing height can be computed even in the absence of vertical temperature structure with the knowledge of $\sigma_{oD}$ with a fair degree of accuracy.

The spatial distribution of sulphur dioxide concentrations shows different pattern in different months according to the meteorological conditions. In most of the cases the western and southern parts of Madras metropolitan area appear to be relatively free from pollution and the northeastern sector is almost always polluted. It is suggested that a 25% reduction in the emission will bring down the concentrations within the permissible limit. It is felt that instead of reducing the emission, the stack height could be raised by 20% which could reduce the concentrations by 50% within the first few kilometres. The extreme southwestern part would be the first choice followed by southeastern and extreme western parts, for further industrial development.

## M.S.116. JALAJAKUMAR, V.S.–Parasite distribution and Histopathological Studies on certain commercially important Fishes of Cochin area–1989–Dr. V.J. Kuttyamma

Investigations were carried out on the distribution of parasites and histopathological effects on certain commercially important fishes of Cochin area. The literature related to the prevalance, mean intensity of infection and histopathological changes cuased by the metazoan parasites, in particular by helminth, copepode and isopods, was reviewed.

Observations were made on the distribution pattern of parasites in relation to the season, sex and size of the host. It was found that the prevalence rate of *Rhadinorhynchus indicus* infecting the alimentary canal of the fish *Tachysurus maculatus*, *Ergasilus* sp. infecting the gills of *T. maculatus*, and *Lernaeenicus ramosus* found on the body surface of *Nemipetrus japonicus* was higher during monsoon season. But *Agarna malayi* found in the opercular chamber and *Philometra cephalus* infecting the gonads of *Valamugil speigleri* showed a higher prevalence rate during the post monsoon season. This is discussed on the basis of the hydrographical characteristics prevailing in the sutdy area during the three different seasons. It was also observed that the sex of the host did not influence significantly the distribution pattern of the parasites. Invariably, the size of the host was found to influence the parasite distribution pattern. It was observed that the prevalence rate showed an increase with increase in size of the fish. This was discussed on the basis of food habits of the host, along with other aspects. The histopathological effect of the various parasites on their respective sites of attachments on host fishes, was studied. It was found hthat except *Raddinorhynchus indicus*, all other parasites produced damages of varying intensity, in the form of hypertrophy, hyperplasia, haemorrhage, tissue disruption and ulcers. In *V. speigleri* the ovary infected with *Philometra cephalus* was less glossy in appearance. Infected ovary was swollen when compared with the uninfected one. Fibrosis of the ovarian tissue, atrophy, displacement, and haemorrhage of primary and secondary oocyte was observed. The movement and feedding of the worm produced severe mechanical damage to the ovary.

A continuous increase in the deposition of a black pigment was observed. The acanthocephalan parasites, *Rhadinorhychus indicus* found in the intestine of *T. maculatus* was found not to cause any serious damage to the intestine of the host fish. The gill filaments of *T. maculatus* infected with *Ergasilus* sp. showed hypertrophy at the point of attachment. Fusion of adjacent gill filments was observed. The operculum of *V. speigleri* which harboured *Agarna malayi* became transparent due to the complete destruction of tissues covering it leaving the calcurious skeleton alone. Gill filaments were found broken at many places, thus reducing the surface area of gill available for respiration. There was excess mucous production. The copepod *Lernaenicus ramosus* inecting *N. japonicus* produced ulcer-like opening at the point of attachment. The scales at the point of attachment was destructed. The skin surface was found to be hyperaemic and swollen. Degeneration of muscular bundles was found around the bulla of the parasite that penetrated into the muscle.

## M.S.117. SUNDARESAN PILLAI, J.–Studies on siltation in Cochin Harbour–dynamics of suspensate–1989–Dr. P.N. Krishnan Nambisan.

Cochin harbour is situated on the southwest coast of Indian peninsula at 9° 58' N and 76° 14'E.

Cochin estuary provides safe anchorage even during the roughest monsoon months. Its location on the southwest coast of India makes it an easily accessible port on the sea routes from Europe and Middle East to Japan, Far East and Australia. The Cochin harbour in its pressent form was developed by Sri. Robert Bistow and was declared as a major Port in 1936. The harbour has an approach channel of 7.8 km long and 200 m wide and two inner channels viz. Mattancherry Channel 5 km long and 225 m wide and Ernakulam channel 6 km long and 225 m wide. The port has twelve berths on Willingdon Island of which nine are wharf type. The two tanker berths in the Ernakulam channel are connected to the mainland. An inshoreoil-terminal has been commissioned recently.

Geographically, the location of this harbour serves in a significant way to the betterment of country's economy; however, the port operations are restricted in a number of ways. Siltation one among them, has been a menace eversince the construction of this harbour. The thesis encomprises the results of an investigation conducted on the problems of siltation in this habour. The dynamics of the suspended material in the navigational channels of the Cochin estuary is highlighted in the study.

To circumvent the problem of siltation in navigational channels, continuous dredging at considerable cost is being carried out. The approach channel is being dredged once every year to a depth of 12.8 m. This channel silts to a depth of 9.75 m per annum. Of the inner channels, the Mattancherry channel is maintained to a depth of 9.75 m and Ernakulam channel 11.6 m. The annual maintenance dredging in the approach channel is about 1.54 $Mm^3$ and in the inner channel 0.7 $Mm^3$. The cost of maintenance in dredging incurred by the Port works out to be Rs. 862.80 lakhs per year (1984-86). Thus the cost involved in dredging operations is an enormous amount, a financial commitment recurring annually and constanly increasing too.

Dredging was once conceived as the final solution to siltation problems. However in recent years, better innovative techniques have been evolved in the Science of harbour engineering. Any form of advancement in the new technological directions necessitates the scientifically gathered data of the system. The research work reported in this thesis provides valuable environmental data on the siltation aspects of the Cochin estuary. Based on the information from environmental data collected, a comprehensive analysis has been made on the dynamics of suspended solids transport, depositional behaviour and ultimate transfer to open sea. The role of estuarine dynamics controlled by river discharge and tidal currents have also been critically examined taking into account the influx of alluvial particulates.

The thesis is presented in six chapters. Chapter I presents a short history on the development of the Port, present facilities and perspectives and introduces the problems of siltation, behaviour of suspensate in the estuarine environement and the scope of the present studies.

The Chapter II details the materials and methods adopted in this study.

The Chapter III deals with the hydrography of the Cochin harbour area and its estuarine environment. Monthly data on temperature and salinity collected from Mattancherry channel, Ernakulam channel and Approach channel are presented in figures, tables and discussed. Time series tidal variations of these parameters on a spring and neap day were worked out at 5 (five) stations. The freshwater fraction in each of these channels were calculated and the dilution of seawater studied seasonally.

The Chapter IV on estuarine dynamics report the results on the studies of water currents measured from fifteen stations in the harbour area. The longitudinal and vertical variations in the speed and direction of estuarine currents caused by the interaction of tides and river discharges have been closely observed. Current variations in the three channels have been discussed separately and supplemented with data on tides, wind speed and direction and river discharges. Current measurements were also made during springtide and neaptide cycles and the temporal and spatial variations included in this chapter.

The temporal and spatial variations of the amount of suspensate and texture of bottom sediments are presented in Chapter V. The dynamics of the suspended material are clearly presented. Surface sediment samples alone subjected to sieve and pipette analysis and sand, silt and clay fractions are plotted on equilateral triangular diagrams. The analysis of results follow the extent of tidal influence on suspended solids distribution and discusses the nature of sedimentation in these coastal waters. The role of estuarine dynamics in modifying the harbour physiography is presented in detail.

Chapter VI summaries the results of the study; suggestions for further investigations are also made and recomends remedial measures. Annexure I provides a detailed account on the dredging operations conducted in Cochin harbour compiled from the bathymetry charts of the Port.

## M.S.118.ANNEY K. MATHEW–Studies on some aspects of biology of two estuarine fishes *Megalops cyprinoides* and *Scatophagus argus*–1989–Dr. A. Antony

*Megalops cyprinoides* and *Scatophagus argus* are the only representatives of the family Megalopidae and Scatophagidae in Indian waters. They inhabit Vembanad lake with varying salinitis throughout the year. Both are favoured as edible fishes rich in nutrients. Besides, Megalops is high ranked as sport fish and scatophagus as aquarium fish due to their unique body structure and appearance.

The basic biological aspects necessarily to be known, while culturing an organism, such as food and feeding habits, proximate composition and the deleterious effects of chemicals unavoidable in culture farms on the physiological systems of the exposed animals are considered for the present study. Significance of the various parameters selected for investigation can be summarised as follows.

For the successful culturing of an organism, a deep knowledge about the food and feeding habits of the organism at different stages of growth and the food preferences in different habitats is inevitable. So fishes of different size groups were colleced from different habitats and their gut contents were analysed. Before recommending a species to be cultured as food fish, their nutrient status and calori content should be estimated. Taking this aspect into consideration, as assessment of the biochemical composition of the edible tissues namely muscle and liver was made.

Copper sulphate is the most popularly used chemical in culture farms for therapeutic purposes. Though copper is metabolicaly essential and therapeuticaly inevitable, it becomes toxic to the exposed animal beyond safe limits. Considering this point of view, fishes were exposed to two sublethal concentrations of copper ie. 0.1 ppm and 0.15 ppm and its effect on selected physiological systems were investigated.

Since blood is a very efficient connective tissue providing access to each and every cell of the body, can reflect the stress experienced by the animal even in minute level. So the variations caused by $Cu^{++}$ on the normal concentration of the various entities such as haemoglobin content, erythrocyte content and leucocyte content was studied.

Variations induced by $Cu^{++}$ on the activity of few important enzymes were also analysed. Of them, two are acid phosphatase and alkaline phosphatase which are hydrolytic in nature and so considered as indicators of stress by fishery biologists. Moreover acid phosphatase is bound to lysosomes wich are the subcellular structure to concentrate, disintegrate and eliminate toxicants while akaline phosphatase is bound to cell membrane which is the subcellular unit first to encounter an external challenge. Two other enzymes studied are Glutamic pyruvate transaminase (GPT) and Glutamic oxaloacetic transaminase (GOT) which catalyse biological transmination - the prime mechanism involved in the synthesis of amino acids and keto acids which are responsible for the overall flavour of fish. Besides transaminases also have a key role in the detoxification of ammonea in toleosts and also autolytic degradation of muscle protein. So variations in their activity is used as yard sticks of stress. The tissues used for analysis are liver which is assigned with the detoxification of toxicants and kidney with the function of physiological elemination.

$Cu^{++}$ when toxic may create hypoxic or anoxic conditions compelling the animal to switch over to anaerobic metabolism. As glycolysis is the pathway for anaerobic metabolism, accumulation of lactic acid, the end product of glycolysis is the immediate manifestation of hypoxia in animals. Since muscle and liver glycogen are the sudden substrates for glycolysis, an estimation of glycogen and lactic acid content of the muscle and liver tissue will provide an idea about the hypoxic stress caused by the copper ions.

It is hoped that the results of the present study will be helpful in formulating suitable schemes for the successful culture and exxploitation of quality fishes in general and the two fishes selected for study in special since very little studies has been made of the two fishes so far.

## M.S.119. VIJAYAN, K.K.–Studies on the Physiology of moulting in the penaeid prawn, *Penaeus indicus* H. Milne Edwards–1989–Dr. A.D. Diwan

Penaeid prawns form the most economically significant group in the marine and brackishwater fishery resources of India. This particular group contributes about 62% of the total prawn landings of the country. At present prawns have assumed an important place especially as a commodity supporting an export trade of sizable magnitude. Considerable interest has been shown in the last decade to increase prawn production through various culture practices, mainly due to the high demand for good quality prawns for export coupled with the stagnant and even depleting nature of marine catches.

Available informations suggest that among the 15 species of shrimps and prawns occurring in Indian waters, which are deemed suitable for aquaculture, the Indian white prawn *P. indicus* is identified as one of the most important commercial species. Considering the increasing importance as an accepted species for prawn culture, *P. indicus* was selected for the present study. In the life history of prawns, moulting is an important event, which enables the animal to achieve growth. This dynamic physiological event continues through out the life span of the prawn, linking almost all biological activities with this process. Hence, a good knowledge pertaining to the physiology of moulting is imperative to understand the growth process of prawns.

Pioneer workers like Drach in 1939 and Sheer in 1960 initiated the classic studies on crustacean moulting physiology. In subsequent years a great deal of information has been added to this particular field by a number of workers viz., Passano, Aiken, Cooke and Sullivan, Stevenson, Skinner, and Fingerman. In spite of these great contributions, only limited attention was received to the moulting physiology of natantians especially of penaeids. In this context an effort is made, through the present work, to study some aspects of the moulting physiology of *P. indicus*.

The main objectives of the present study are:

1. To draw a scheme for the moult cycle classification, and identification of sequential stages of the moulting process.
2. To understand the physiology of moulting in relation to following aspects:
   a) The structure and function of endocrine systems in relation to moulting process
   b) Studies on the behaviour of important metabolites during the moulting cycle
   c) The structure of the cuticle and mapping of some of the important minerals viz., Calcium, Magnesium and Phosphorus and investigation on the mobilization of these minerals during moulting process.
   d) The effect of some environmental and other factors on moulting process

The thesis consists of five chapters, with preface, general introduction and the objectives of study in the beginning. Each chapter has an introduction, followed by materials & methods, results and discussion. Introduction of each chapter highlights the importance of the particular aspects of study covering a review of literature. Under materials and methods the methodology used, and in the results the data obtained are presented. Each chapter is concluded with a discussion followed by a short summary.

The first chapter deals with the characterization and classification of complete moult cycle on the basis of setal development (setagenesis) and cuticle histology. Duration of each moult stage, effect of body size on moult cycle duration, and moulting behaviour are also investigated on the basis of moult experiments.

The second chapter deals with the structures of endocrine systems and their mechanisms of control on moulting process of the animal. Investigations on the structure and changes of endocrine centres, such as X-organ Sinus Gland complex (Eye), Brain & thoracic ganglia are made using standard staining techniques. Y-organ or the moulting gland and mandibular gland have been found out and their positions were confirmed with histological studies. Alterations in the size and tinctorial affinity of Y-organ cells were noted between the moult stages. Eyestalk ablation and Y-organoctomy experiments revealed the production of moult controlling factors in X-organ during the moulting cycle of the prawn.

The third chapter is on role and involvement of some important metabolites like protein, DNA, RNA, Lipid, glycogen, glucose, glucosamine, chitin, and water content during the moulting cycle of the prawn. Metabolites were estimated in selected tissues such as muscle, hepatopancreas, cuticle and haemolymph of the animal. Profound changes in the concentration of metabolites were observed during the different stages of moult cycle, especially between early premoult and postmoult stages.

The fourth chapter is on the structure of cuticle, and distribution and mobilization of some important minerals of the exoskeleton viz, calcium, magnesium and phosphorus. Cuticle structure is studied using histological and histochemical techniques. The bio concentration of calcium, magnesium and phosphorous was estimated in different tissues such as exoskeleton, muscle, hepatopancreas and haemolymph with changing stages of the moult. Among minerals calcium was found to have a major share and showed significant changes between the moult stages. The mapping of calcium, magnesium and phosphorus in different parts of the exoskeleton was carried out to understand the distribution pattern of these minerals in the exoskeleton.

In the fifth chapter, observations on the effect of some important environmntal factors like temperature, salinity, pH, light, and the effect of other factors like starvation and autotomy on moulting cycle of the prawn are included. In the experimental set up, along with the moulting cycle, growth pattern of the prawns was also monitored to find out the effect of environmental factors on growth. Temperature was observed to have prime and direct control over the process of moulting. The moulting cycle of the prawn was severely affected due to starvation while autotomy has not produced any significant effect on moulting.

A summary of the work, and bibliography are given at the end.

### M.S.120. SHAHUL HAMEED, T.S.–Spectral and Statistical characteristics of Shoaling Waves off Alleppey–west coast of India–1989–Dr. M. Baba

The present study is conducted with wave records collected systematically from a shallow water location along the Alleppey Coast. Waves are recorded at 3 hourly intervals using a pressure type recorder. The transducer is installed at 3.5 m below the MWL at a station having depth of about 5.5 m. Data Collected during a 4-year period (1980-84) is utilised to determine the wave climate at this location. From the analysis of these records the yearly variation in wave climate is found to be not significant. Hence the data covering a complete year is selected for the detailed study of the spectral and statistical characteristics of the shoaling waves. The wave spectra are computed using the FFT algorithm and the height, period and their joint distributions are derived using the zero-up-crossing method of analysis.

The wave climate at this location is influenced by the south-west monsoonal winds. During May-September the waves are characterised by larger heights associated with comparatively shorter periods an narrow spectrum.

Multi-peakedness observed in almost all the spectra at this shallow water location is due to the co-existence of wave trains of different characteristics. Hence the secondary peaks are not at the higher harmonics of the peak frequency, as observed in some other shallow water locations. The spectral peakedness parameter Qp does not show any characteristic properties with the wave climate.

The average spectra for different energy ranges show dependence of slope of the high frequency side of the spectrum on energy.

A new spectral model (PMK spectrum) is developed for the prediction of shallow water waves following the theories of Pierson-Moskowitz (1964) and Kitaigorodskii et al. (1975), and is calibrated with the observed spectra. The observed spectra are also compared with Kitaigorodski et al.'s model with Jensen's modification, the TMA model in its original form and with a few modifications, the Wallops model and the GLERL model (Liu, 1983).

The shallow water dispersion relationship of Kitaigorodskii et al. (1975) is a useful tool to transform the deep water spectral models to the shallow waters. The models derived using this relationship are able to predict the shallow water spectrum correctly when suitable scale parameters are used. Those which are functions of the total energy are found to be good scale parameters.

The models which depend entirely on the peak frequency simulate the spectrum correctly at high energy cases (Hs $\geq$ 2.5 m) only. The TMA model in its original form (with 5 free parameters) simulate the shallow water spectra in a large number of cases. This model is particularly useful for high energy cases where Hs is of the order of 1.4 m and above. The peak energy density is predicted correctly by this model, but the total energy is overestimated, especially in the low energy cases.

The short-term distributions of wave heights computed from the data are compared with the distribution functions of Rayleigh, Goda, Weibull, Gluhovskii, Ibrageemov, Tayfun, Longuet-Higgins (1975 and 1983 models) and CNEXO in the original form and with the modification suggested by Vincent (1984). The depth-dependent models simulate the observed distributions better than the others.

Among the presently available ones, Tayfun's model is the only one capable of simulating it satisfactorily in a large number of cases.

The joint distribution of zero-crossing wave heights and periods deviate from symmetry. Though the shape of the distribution resembles with CNEXO and Longuet-Higgins' modified forms, the modes are incorrectly placed by these models. The Rayleighean models fail to simulate the joint distribution in most of the cases. Tayfun's model predicts the modes of the distribution close to the observed. Best results are obtained with this model in the Hs range of 0.25-1.75 m. The Tayfun's model can be used for the low fair weather waves and the modified CNEXO model can be used for the high energy monsoonal waves, to determine the joint distribution.

## M.S.121. VINCY SAMUEL–Some Histological Studies on the Indian White Prawn Penaeus Indicus H. Milne Edward, 1873–1989–Dr. V.J. Kutty Amma

The availability of seed and relatively faster growth makes the penaeid prawn *Penaeus indicus* apparently superior candidate for culture and is an ideal species for farming in Kerala region. With the increasing interest in the aquaculture of this species, a study of its histology becomes necessary for a better diagnosis and control of diseases. The present study has mainly dealt with the histology of some of the organ systems in*P. indicus.*

Histological and histochemical nature of the different layers of the integument and the tegumental glands seen among the epidermal cells have been studied in detail. The gills are the primary sites of respiration and osmo-regulation. The description of the gills, showing different cell layers and the structure of the gill filaments gives a detailed information on this aspects of study. The structure and histology of the various regions of the digestive system, such as the oesophagus, cardiac foregut, puloric foregut, hepatopancreas, midgut, anterior and possterior diverticulam and hindgut are given. The hepatopancreas in *P. indicus* include four types of cells viz; Embryonic (E-) cells Absorptive (R-) cells, Fibrillar (F-) cells and secretory (B-) cells. The secretory (B-) cells show spocrine mode of secretion.

The neurosecretory cells of the eyestalk, brain and thoracic ganglion are being described. Three types of cells viz; cell type I, cell type II and cell type III could be identified in the eyestalk, brain and thoracic ganglion. The X-organ is composed of only Type II cells. The position of the sinus gland which forms the well known realizing centre of the hormones is also given. The histology of the ovary and testis oogenesis and spermatogenesis and the histology of vas deferens is given. The spermatozoa in *P. indicus* has a round body with a single spike. In the vas deference of *P.* indicus of size 130 mm four regions could be distinguished. The epidermal cells of the integument diminish in size during postmoult and intermoult upto early premoult, after which they grow. Glycogen is stored in the epidermis and connective tissue during intermoult and early premoult, suggesting that it may be utilized in the formation of chitin. Changes are occurring in the tissues of integument, gill and hepatopanchreas when the specimens are exposed to cadmium and Ekalux. The integument, after six days exposure to cadmium showed blackened cuticular lesions, where as integument after six days of exposure to Ekalux showed little change, when compared with the controls.

## M.S.122. SHAJU THOMAS–Studies on the fresh water copepod fish parasites of Kerala–1989–Dr. M. Shahul Hameed.

The thesis gives a detailed account of five new species of fresh water copepod fish parasites, life history and host-parasite relationship. For the first time in India life history of a fresh water copepod was successfully done in the laboratory conditions. To eradicate the parasitic attack on cultural ponds different treatment methods were tried and suggested a suitable one for further use in this field.

In the life history of *Lernaea osphronemi* sp. nov. there are nine larval stages but no intermediate host for the parasite to complete the life cycle. The life span of the parasite is established as 20-25 days. The experiments conducted with *Tilapia mosambica* as a biological control proved to be successful. The parasitic attack on fresh water fishes can be controlled both by chemical and biological treatment as per the investigation carried out.

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